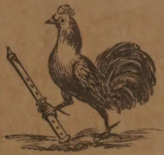

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ELEMENTS

OF

PHYSIOLOGY.

IN TWO VOLUMES.

dup. keep

Elements of Physiology;

BY

JO. FRED. BLUMENBACH, M.D.

PROFESSOR OF MEDICINE IN ORDINARY AT GOETTINGEN, MEMBER OF THE ROYAL SOCIETY OF SCIENCES AT GOETTINGEN, AND OF SEVERAL OTHER SOCIETIES IN DIFFERENT PARTS OF EUROPE.

Translated from the Original Latin,

AND

INTERSPERSED WITH OCCASIONAL NOTES.

By CHARLES CALDWELL.

TO WHICH IS SUBJOINED, BY THE TRANSLATOR,

An APPENDIX,

EXHIBITING A BRIEF AND COMPENDIOUS VIEW
OF THE EXISTING DISCOVERIES
Relative to the Subject of

ANIMAL ELECTRICITY.

VOLUME I.

PHILADELPHIA,
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M.DCC.XCV.

TO

THE PROFESSORS

OF THE

VARIOUS BRANCHES OF MEDICAL SCIENCE
IN THE UNIVERSITY OF PENNSYLVANIA.

GENTLEMEN,

LONG have you been my *fathers* and long my attentive *preceptors*, in the intereſting ſcience of medicine. You juſtly hold on me, therefore, a twofold claim for the twofold duty of a pupil and a ſon. In reſpectful acknowledgement of this undeniable claim, I now ſtep forward and thus publicly ſolicit your acceptance of the *firſt fruits* of that medical education, which you yourſelves were pleaſed to

to patronize and direct with ſuch ability and care.

Avowedly to ſolicit an extenſion of your immediate patronage and protection to the following tranſlation, would be to offer you an indignity little ſhort of actual inſult. Such a ſolicitation would falſely repreſent you as men unwilling to become the ſpontaneous guardians and friends of ſilent, unaſſuming truth and merit, but ſtanding with open arms for the reception even of intruſive error itſelf, when uſhered to your notice by a brazen front and a blanditious tongue.

The original work of Profeſſor Blumenbach has been already ſanctioned

tioned by the applauding voice of the learned and the ingenious in almoſt every part of the globe to which phyſical ſcience has hitherto found its way. On the ſolitary baſis of its own intrinſic merit let my *tranſlation* alſo ſtand; or if, indeed, it be deſtitute of ſuch baſis, with diſgrace let it ſink into that ſea of oblivion which ſo juſtly awaits its final reception.

From you, Gentlemen, it is ſecure of at leaſt, a patient, and, I flatter myſelf, an impartial examination. Should the execution of the work fortunately meet with your approbation and applauſe, you will be its auſpicious announcers to the medical public: but ſhould it appear to you faulty and

even

even wholly unworthy of further attention or regard, you will not, I am ſure, loſe ſight of that favourite maxim of the humane and generous boſom, "*primum peccatum veniandum eſt.*"

Impreſſed with the moſt profound ſentiments of eſteem and gratitude for your favours of a public nature, as well as for your attentive acts of private friendſhip, I have the honour to be,

Your ſincere Friend,

And Pupil,

THE TRANSLATOR.

PHILADELPHIA,
February 11, 1795.

Preface by the Tranſlator.

WHAT a faſhionable letter of introduction is to its bearer, a faſhionable preface is to the literary performance which it openly announces to the world. The former procures, for the moſt part, admiſſion, and, at leaſt, a dinner ; the latter moſt commonly an attentive peruſal. For their future continuance, however, in favour and eſteem, both the viſitant and the volume muſt depend on ſomething more ſubſtantial, and of more unequivocal utility, than either the light etiquette of a letter, or the ſpecious propoſals of a recommendatory preface.

The

The reader is requested to view the present prefatory address as a mere peace-offering, made by the translator to ancient and inveterate custom, and not as a solemn appeal to the public designed to enhance either the *merit* of the following *performance*, or the *uprightness* of the *motives* which led to its execution. For with regard to the *merit* of the work, I flatter myself that no character of literature and talents will ever resign his right of judging for himself; and as to the *motives* by which I was induced to engage in its translation, they are indeed at present nothing better than absolute non-entities, and will in no way effect its utility to man.

The want of a new and complete system of physiology has been long and very sensibly experienced and regretted by all medical students on this side the Atlantic. As to myself, I am sure I was led most devoutly to regret

regret ſuch a want, throughout every ſtage of my medical ſtudies. In order to acquire a knowledge of the improvements which had lately taken place in this important branch of phyſical ſcience, I was obliged to range with an infinitude of labour and attention, through daily accumulating volumes, which it was ſometimes extremely difficult to procure. This difficulty was augmented even to impoſſibility itſelf with thoſe unfortunately living out of the ſphere of public libraries.

The mutilated abridgment of Haller's phyſiology, publiſhed in the Engliſh language, is (to uſe a common mode of expreſſion) certainly nothing more than a *bare apology* for a ſyſtem. It is imperfect, erroneous, and, in many places, to me wholly unintelligible. In ſome parts, therefore, it no doubt inculcates truth, in others implants

the

the ſeeds of error, and in other places again leaves the young mind at liberty to indulge itſelf in all the wildneſs and revelry of conjecture.

For theſe deficiencies and faults, I am ſure that at leaſt ſome compenſation is made, and ſome degree of remedy provided in the following ſheets, which I am about to uſher forth to the world. But on this ſubject let deciſion be awarded, and judgment pronounced, by the candid and intelligent reader, and not by

His obedient humble Servant,

THE TRANSLATOR.

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VOLUME II.

ELEMENTS

OF

PHYSIOLOGY.

SECTION I.

OF THE LIVING HUMAN BODY IN GENERAL.

§ 1.

IN the living human body, the healthy functions of which constitute the exclusive object of the science of Physiology, there occur three things worthy of our immediate attention and regard*; namely,

The *Solids*, or parts containing;

* In an ancient volume commonly ranked among the writings of Hippocrates, *Epidemic.* VI. Sect. 8. § 19, we find the following remarkable clause: "Quæ continent corpora, aut "intus continentur, aut in nobis cum impetu moventur "contemplanda sunt." This celebrated clause furnished Abr. Kaau Boerhaave with the first hints and suggestions

The *Fluids*, or parts contained within the ſolids;

And laſtly, the *Vital Energies*, which in the conſideration of the ſcience of phyſiology, conſtitute the moſt intereſting and important object of our regard. It is in conſequence of theſe energies that the ſolids are rendered alive to the impulſe of the fluids, endued with a power to propel the ſame, and alſo to perform a variety of other motions. It muſt however be obſerved, that theſe energies are not incommunicably excluded even from ſome of the fluids themſelves: on the whole, they appear to conſtitute the eſſence or ſupreme characteriſtic of an organiſed body.

§ 2.

But although theſe three *objects* have been with propriety conſidered as diſtinct from each other, and may therefore be ſeparately enumerated on the preſent occaſion, they are notwithſtanding in the living body, which is alone the excluſive ſubject of phyſiology, ſo intimately connected together, that it is ſcarcely poſſible to form even a conception of one without at the ſame time embracing the others.

on the ſubject of his ineſtimable work entitled, "Impetum "faciens dictum Hippocrati per corpus conſentiens." L. B. 1745-8.

The

The moſt pure and limpid fluids of our body abound with animal earth: on the other hand, though our ſolids may appear to us completely deſtitute of liquid matter, yet, beſides the circumſtance of their originating from the fluids as their *matrix* or primary ſource, they contain in their compoſition an evident quantity of moiſture: laſtly, if we be not deceived, it is certainly true that there exiſts ſcarcely a fibril in the living body which does not poſſeſs, in a higher or lower degree, a vital energy inherent in itſelf.

§ 3.

We now proceed to treat of each of thoſe three objects ſeparately and in order: and firſt of the fluids; as conſtituting by far the *greateſt*, and what may be emphatically called the *firſt-born* part of our bodies.

SECT. II.

OF THE FLUIDS OF THE HUMAN BODY IN GENERAL, AND OF THE BLOOD IN PARTICULAR.

§ 4.

ALL the different fluids of our body, may with propriety be thrown into three leading claſſes.

 Theſe

Thefe are, I. The *Crude* or unaffimilifed fluid, confifting chiefly of the chyle contained in the primæ viæ, and deftined for converfion into blood; to which may alfo be added, *that fluid* received by abforption from the external fuperficies of the body, and conveyed to the fame receptacle with the former.

II. The blood itfelf;

And Laftly, the *fecreted fluid*, or that formed from the volume of blood by the animal procefs, called fecretion: the fluids prepared by this procefs are deftined, fome of them, to be retained in our body, to ferve further purpofes in the animal economy; and others, to be eliminated from our fyftem, as wholly excrementitious.

§ 5.

Of the firft and third of thofe claffes we will fpeak on a future occafion, when we come to treat of chylification, and of fecretion, together with the other functions to which thofe fluids are refpectively related. Let us now proceed to the confideration of the blood, that moft important, that primary, and truly vital liquid, which may with the greateft propriety be called, the living fountain of all the other fluids; as being that *into* which the crude fluid is converted; and *from* which all the

the ſecreted fluids derive their origin; and which (a few parts of the body excepted, ſuch as the epidermis, the *tunica arachnoidea*, the amnion, the vitreous ſubſtance, or enamel, of the teeth, &c.) flows uniformly through every even the moſt minute and fine ſpun parts of the inexplicable texture of our ſyſtem.

§ 6.

The blood is a liquid *ſui generis*, of a well known colour, more or leſs intenſe: it is glutinous and warm to the touch: the formation of this liquid has hitherto been ranked among the *arcana* of nature, as it has never been ſucceſsfully imitated by any proceſs of art.

§ 7.

This vital liquid when recently drawn from a living ſubject, and received into a veſſel, exhibits in a very obvious manner the following remarkable phenomena:

In the firſt place, while it is yet warm, a ſubtle halitus aſcends from it, which being collected in a receiver, forms ſmall pellucid globules, ſimilar in appearance to drops of dew; it is of an aqueous nature, reſembling not a little common fountain water, except that it emits a peculiar nidorous ſmell, (ſtill more conſiderable in the blood of car-

nivorous animals) and which may be aptly called the *animal odour;* ſuch, for example, as ariſes from freſh urine, or from the thoracic and abdominal cavities of a dead ſubject recently opened. Of this aqueous liquor a conſiderable quantity remains in a ſtate of mixture with the other conſtituent parts of the blood, which ſhall be hereafter mentioned.

§ 8.

In the mean while, as the blood contained in the veſſel ſuffers a gradual reduction of temperature, it begins to ſeparate into two parts. A coagulum is firſt formed, from the ſuperficies and ſides of which, there preſently exſudes a liquor of an intermediate ſhade between pale yellow, and evaneſcent red, which they call the *ſerum* of the blood; in proportion as this liquor accumulates by exſudation, a correſponding diminution is obſervable in the volume of the coagulum itſelf; the coagulum thus reduced in ſize has been diſtinguiſhed by the name of *craſſamentum*, as alſo by thoſe of the *liver*, and *placenta* of the blood, from a reſemblance, in point of colour and frangibility of texture, ſuppoſed to exiſt between it and theſe two bodies; it has been likewiſe called *the iſland*, from the circumſtance of its being held in a natant or floating ſtate in the ſurrounding ſerum.

§ 9.

§ 9.

This craſſamentum itſelf, by a delicate treatment, ſuch as gentle agitation or frequent ablutions in water, may be again ſeparated into two conſtituent parts, viz. the *cruor*, which imparts the red colour to the whole maſs of blood, and which by ablution is carried off from the *lymph*, the other and more ſubſtantial part, and which, therefore, is called the baſis of the craſſamentum; that the cruor retains for this baſis a much ſtronger affinity than the ſerum poſſeſſes, is ſufficiently obvious from this circumſtance, that the cruor and baſis cannot be diſparted unleſs by the interpoſition of a certain degree of force. The lymph itſelf being robbed of the cruor, becomes more and more pale until it finally aſſumes the appearance of a white and conſiderably tenaceous coagulum.

§ 10.

Such then appears to be the four principal conſtituent parts of the blood,—viz. the watery *halitus*; the *ſerum*; the *cruor*, or red globules; and the coagulable *lymph*; which ſeveral parts, as long as they retain their native degree of vital temperature, continue in a ſtate of the moſt equable mixture, conſtituting an uniform and homogeneous fluid.

 It

It will now be proper to enter into a more minute confideration of thofe three portions of the blood which ftand laft in the above enumeration: As to the aqueous exhalation which we have mentioned, it does not appear of fufficient importance to claim any further attention; indeed as it is alfo difcovered in other parts of the body, it cannot be confidered as proper to the blood alone, any more than the air which this vital fluid contains, and on which we will ftate a few obfervations in a fubfequent part of this fection.

§ 11.

The ferum is a liquid of fuch a gelatinous nature as to impart to the whole mafs of the blood the chief part of its vifcofity or gluey confiftence: it very much refembles, in all its properties, the albumen or white of eggs; when fubjected to the action of a temperature equal to the 150th degree on the fcale of Fahrenheit's thermometer, it paffes into a coagulum, white and eafily broken down, analogous to the white of eggs in a boiled ftate; it alfo fuffers a fimilar change, according to the experiments of the celebrated Mofcati, if it be mixed with a quantity of quick lime, though in this cafe the coagulation proceeds much more flowly, and is not completed till after the twentieth hour. But if the ferum be dried with a gentle heat, and left wholly undifturbed, it is converted

converted into a firm pellucid mafs, fimilar in its external appearance to gum arabic, which in a gradual manner, like the dried white of eggs, cracks and forms over its furface numerous *fulci* or fiffures running in a fomewhat fpiral direction, and exhibiting a very fingular appearance.

§ 12.

Befides thofe other properties of the ferum already mentioned, there is one highly worthy our confideration, to which my attention was firft called by the experiments of the illuftrious Prieftley *; but my belief of which has fince been fully confirmed by repeated obfervations of my own, viz. the facility with which the air, furrounding a veffel filled with blood, is able to act through the medium of the ferum or the craffamentum, though deeply covered by the former, in fuch a manner as to produce a very remarkable change in the colour of the latter, whereas, on the other hand, the fame action of the air would be very much impeded, if not entirely prevented, if inftead of the ferum, the craffamentum were covered with any foreign liquid, fuch as water, or oil, &c. or even with any other fluid of the human body itfelf, as the faliva or urine.

* Philof. Tranfact. vol. LXVI. P. I. pag. 244, feq.

§ 13.

§ 13.

The cruor conſtitutes another very ſtriking and important part of the blood, and is a ſource of many ſingularities, whether we conſider the colour and figure of its particles, or the elementary parts into which it is reſolved when ſubjected to the action of an intenſe heat. It appears to deſerve a place among the moſt elaborate juices of the body, as it ſeldom appears in the tender fœtus previouſly to the fourth week after conception, nor in the naſcent young of gallinaceous fowls till the fortieth hour of incubation. After profuſe hemorrhages it likewiſe appears to be replaced by the powers of the ſyſtem, with much more difficulty than the other conſtituent portions of the blood.

§ 14.

It conſiſts of globules, firſt obſerved by Leeuwenhoek. In blood recently drawn they are always preſent, of a conſtant, uniform figure, and of an equable magnitude; which circumſtances, added to the further conſideration, that in no other fluid (milk alone excepted, the particles of which are ſomewhat analogous), are ſimilar bodies to be met with, leave not a ſhadow of doubt, but that thoſe globules form a part very obviouſly and eſſentially different from the other conſtituent portions of the blood, though at the ſame

ſame time the formation of thoſe globular bodies themſelves appears in reality to be much more ſimple than ſome celebrated characters would induce us to believe. For to paſs over in ſilence the complexity of the ſixfold form fictitiouſly beſtowed on them by Leeuwenhoek, neither the annular figure attributed to them by the illuſtrious de la Torre, nor the form of veſicles encloſing an opaque nucleous, ſuch as Hewſon apprehended he diſcovered in them, have appeared to me to be well founded*. In my obſervations, indeed, I have been able to detect nothing more than bodies of a ſimple ſpherical appearance, and, if I am not deceived, of a ſolid gelatinous conſiſtence. I have not, indeed, abſolutely denied the lenticular figure beſtowed on them by ſome obſervers: I dare not, however, venture to aſſert, that I have been ſo fortunate as to obſerve it.

It has been a ſubject of controverſy whether or not they can alter their figure when it becomes neceſſary for them to paſs through a veſſel of a very narrow diameter. I am inclined to believe, in conformity to the opinion of that accurate obſerver Reichel that under the above circumſtances, they do actually change their ſpherical for an oval figure, and again reſume their former

* Philoſ. Tranſ. Vol. LXIII. P. II. p. 303. ſeq. tab. XII.

globular

globular ſhape, when they advance into veſſels ſufficiently capacious; though I muſt confeſs, I never had the happineſs to be a ſpectator of this intereſting phenomenon.

This ſpherical figure of the globules is never perceived unleſs in the blood circulating in the veſſels of a living animal, or in that which is recently drawn; they loſe all regularity of form in proceſs of time, and appear to diſſolve, as it were, and again unite with each other into one uniform ſhapeleſs maſs.

§ 15.

Phyſiologiſts differ in determining the ſize of the globules of the blood. Hales reckons them equal in diameter to the $\frac{1}{3240}$th part of an inch. Senac eſtimates their diameter at about the $\frac{1}{3300}$th part of the ſame meaſure, while others again entertain different opinions.

§ 16.

Their colour is red, and therefore the beautiful crimſon caſt of the whole maſs of blood appears to be evidently derived from them. The intenſity of this colour changes with a multiplicity of varying circumſtances; it is more pale in animals which are too ſparingly nouriſhed, or in ſuch as have ſuffered profuſe hemorrhages. The blood con-

contained

tained in the arteries is more florid, together with that which has been ſubjected to the action of *atmoſpheric*, but more eſpecially, that which has been expoſed to *dephlogiſticated* air; while venous blood is more obſcure, as well as that which has been acted on by fixed or inflammable air.

§ 17.

Upon the whole, the cauſes, which augment the quantity of the red globules in general, and alſo heighten the intenſity of their colour, are ſufficiently evident: but to diſcover from what ſecret ſource their diſpoſition to this crimſon dye is originally derived, is a matter of Herculean difficulty indeed. Haller aſcribed it to the preſence of *crocus martis*, becauſe the blood abounds more with iron than the bones, or other parts of the body, although the quantity contained, even in the blood itſelf, is very ſmall; and although authors differ aſtoniſhingly in their attempts to aſcertain it. Thus, for inſtance, Menghinus eſtimated its relative proportion to the whole maſs of the blood, to be as 1 to 110; whereas, the illuſtrious Rhades calculated it to be only as 1 to 427; and again, in ſome future experiments, to be no more than as 1 to 503, &c.

On the preſent ſubject it ſeems proper to make the following obſervation; viz. that no iron can be

be difcovered in the cruor of the blood unlefs it be previoufly calcined; whereas, on the other hand, when it was dried with a gentle heat, and reduced to the moft impalpable powder, I could not obferve a fingle particle of it attracted by the magnet, whether the experiment was made in water, or in that moft fluid of all vehicles, quickfilver.

§ 18.

We now come to the confideration of that conftituent part of the mafs of blood, which ftands laft in our order of enumeration, viz. the *Lymph;* which is by fome called the bafis of the craffamentum, by others, the mucous or glutinous part, and by others, the fibrous portion of the blood.

This, in former times, was very erroneoufly confounded with the ferum, from which it is notwithftanding very widely different, in all its effential properties. When the lymph is expofed to the action of air, efpecially of fuch as is of a low temperature, it is immediately coagulated; but by the admixture of quicklime, (which has been already faid (§ 11.) to have the power of coagulating ferum), it is preferved in a fluid ftate; or, even though it be already coagulated, yet, by the addition of this fubftance, it is again immediately refolved.

§ 19.

§ 19.

We have already touched on the methods, by which this part of the blood may be ſeparated from the cruor (§ 9.). It is alſo by other artificial methods, ſuch as whipping or agitating the blood with ſmall twigs, induced to aſſume the appearance of a membrane, which has been named after Ruyſch its celebrated diſcoverer.

The ſimilitude which prevails between the membrane thus formed by art, and certain remarkable phenomena in diſeaſes, eſpecially in thoſe of an inflammatory nature, reduces it to a certainty, that ſuch phenomena are to be entirely referred to the coagulation of the lymph, of which we are now treating.

It may be proper on the preſent occaſion to mention a few of thoſe numerous phenomena alluded to, which evidently derive their origin from this property of the lymph; thus we may inſtance in particular, the *pleuritic cruſt*, which is formed on the ſurface of the craſſamentum of blood received into a veſſel and ſuffered to remain ſometime at reſt; the *membrane-like* appearances which uſually tranſude from, and completely inveſt the ſurfaces of the ſeveral viſcera when in a ſtate of inflammation; and alſo the *membrana caduca*

of

of Hunter, which exſudes from the cavity of the uterus, when impregnated, and ſtill under the gentle glow of the venereal orgaſm. From the ſame ſource originates likewiſe, that production of cellular membrane by which we ſee frequently the lungs connected to the pleura in caſes of peripneumony; as alſo the preternatural portions of the ſame ſubſtance often found in the cavity of the abdomen after profuſe hemorrhages; and finally, to no other ſource can we rationally refer thoſe membrane-like productions, which, in that ſingular ſpecies of diſeaſe, vulgarly denominated Lithopœdion, firmly attach to the contiguous viſcera ſuch parts as are irritated to inflamation by the too long retention of the calculus or ſtone in the abdominal cavity. It ſeems to be alſo an opinion founded at leaſt on probability, that polypi, and ſuch like preternatural coagulated excreſcences, owe their exiſtence to the ſame cauſe.

§ 20.

Thoſe phenomena juſt enumerated, together with a variety of others which every where occur, demonſtrate, in a moſt ſtriking manner, the ſuperior importance of this lymphatic portion, in which the vital principle of the blood appears immediately to reſide, if indeed the blood poſſeſs any ſuch principle, an opinion which I think both ingenious and highly probable.

§ 21.

Befides thofe general portions of the blood already enumerated, we have on a former occafion obferved that this fluid contains alfo, in a ftate of mixture, other elementary principles. (§ 10.)

What I principally advert to at prefent is *air*, which is commonly believed to conftitute $\frac{1}{11}$ part of the whole mafs of blood, but which in the blood of a living and healthy fubject does not exift in a free and perfectly elaftic ftate, but is fo intimately united and involved, and fo permanently fixed, as to be with difficulty extricated and reftored to its native æriform ftate. Indeed I have learned from actual experiments, that even a very fmall quantity of the moft pure air injected through an artificial opening into the jugular vein of a dog, has excited fymptoms of a very formidable nature, fuch as palpitations of the heart, drowfinefs, convulfions, and, when the quantity was flightly increafed, even death itfelf quickly fucceeded.

§ 22.

The elementary parts of the blood thus concifely treated of, differ very widely in the proportion they bear to each other in different fubjects, according to the complex ratio of age, nourifhment, and other circumftances of importance, which regard the found health of each individual.

§ 23.

Neither has any thing more certain or decisive been advanced with respect to the proportion which the whole volume of blood bears to the entire bulk of the body. Haller was of opinion, that in an adult it amounts to 30 or 36 pounds by weight; while the calculations of others have been widely different.

SECT. III.

OF THE SOLIDS OF THE HUMAN BODY IN GENERAL, BUT PARTICULARLY OF THE CELLULAR MEMBRANE.

§ 24.

THE solids of the body are originally derived from the fluids themselves; thus in the first rudiments of the embryo, while yet in a gelatinous state, the solids, each in its own appropriate situation, begin in a very gradual manner to assume their proper form and texture, infinitely different from each other in point of cohesion, from the most tender and almost pultaceous consistence, such as the medullary substance of the brain, to the most firm and durable, as the vitreous cortex, or enamel of the teeth.

§ 25.

§ 25.

In all the ſolids of the body an earthy baſis of a calcareous nature abounds more or leſs, not indeed in a ſimple ſtate, but united to the phoſphoric and ſaccharine acids, the former of which exiſts in by far the largeſt proportion. Their cohesion depends not only on the peculiarity of their texture, but is alſo much promoted, as well by the quantity of air contained in them in a fixed ſtate *, (which is aſcertained by the experiments of the illuſtrious Hales to be more abundant as the parts are more ſolid); as alſo by the ſubſtance called animal glue, which is procured in large quantities from the ſolid parts of animal bodies, and is in general uſe in ſome of the mechanical arts. The origin of this tenacious ſubſtance may be very eaſily explained and comprehended from what has been already ſaid reſpecting the viſcoſity or gluey nature of the blood.

* "The properties and powers of air have not yet been ultimately developed. It is, however, in the mean time certain, that this ſubſtance conſtitutes, at leaſt, a part of the gluten or cement by which all the more compact bodies in nature are conſolidated and bound together. Thus the diſſolution of metals, bones, ſtones, ſhells, and ſalts, is uniformly attended with an extrication of air." *See* Haller de corp. hum. functionib. Vol. III. pag. 271.

The elementary ſubſtance of iron, to which has been attributed the important office of increaſing the powers of coheſion in the different parts of the human body, ſcarcely deſerves to be taken into conſideration at all, as I have found its quantity to be ſo very minute as not to exiſt in a greater proportion than one fifth part of a grain to two pounds even of the bones, the hardeſt and moſt coherent parts of the animal ſyſtem.

§ 26.

A great portion of the ſolids of our body very evidently exhibits a fibrous texture, compoſed of ſmall filaments running more or leſs parallel to each other. Theſe filaments or fibres may be evidently enough perceived in the bones, eſpecially the bones of a fœtus, in the muſcular fleſh, in tendons, ligaments, aponeuroſes, and ſome membranes, as the dura mater, &c.

§ 27.

In various *other parts* of the animal body, the texture is ſo widely different from that of which we have juſt ſpoken, that in them it is ſcarcely poſſible to trace the appearance of a ſingle fibre; their ſtructure is indeed of a very ſingular and ſpecific nature, diſtinguiſhed in Greek by the name *parenchyma*. This parenchymatous ſubſtance is almoſt excluſively confined to ſome of the ſecreting

viſcera

viſcera of the ſyſtem; thus it exiſts in the kidneys, in the liver, &c. though aſſuming a ſomewhat different and peculiar appearance in each.

§ 28.

Through all thoſe varieties of compoſition and texture, whether of a fibrous or parenchymatous appearance, there is interwoven, in common, more or leſs of a certain web-like ſubſtance, which is called *cellular membrane*, and which deſerves a place among the primary, the moſt important and eſſential, conſtituent parts of our ſyſtem.

§ 29.

For, in the firſt place, there are ſeveral of the ſolid parts of the human body, which appear to conſiſt of little elſe than cellular membrane, in a conſtipated or compacted ſtate; of this deſcription are moſt of the membranes and cartilages; which, by long maceration, may be again reſolved into a cellular web, of more or leſs laxity. It is, again, ſo intimately and minutely interwoven in the compoſition of other parts, as to ſerve the important purpoſes of a receptacle and baſis to the other portions of ſubſtance which aſſiſt in their formation. Thus, for inſtance, the hardeſt bones made their firſt appearance in the tenderer ſtate of cartilage, which, as already obſerved, is nothing more than condenſed cellular membrane: this cellular membrane, yet in a lax condition, became afterwards

 diſtended,

diſtended, and at length completely ſaturated, as it were, by the conſtant acceſſion of oſſeous matter, till it finally aſſumed the nature and appearance of perfect bone. Indeed it would appear, that none of the ſolids of our body exiſt, without containing more or leſs of this web-like ſubſtance in their compoſition, if we except the enamel of the teeth, in which I was not able to diſcover the ſmalleſt portion of cellular ſubſtance, even when the enamel was ſubjected to the action of one of the ſtronger acids.

§ 30.

This cellular ſubſtance, which ſerves the great purpoſe of a boundary, or partition-wall, to adjacent parts, is eſpecially interwoven in, as well as ſpread between, muſcles and membranes. To other parts, again, particularly to veſſels and nerves, it anſwers as a bed or baſis of ſupport. Finally, it conſtitutes one common and general bond of union, which connects the neighbouring individual parts to each other, and eſtabliſhes between the whole an extenſive medium of communication.

§ 31.

From what has been already ſaid, two concluſions naturally preſent themſelves.

Firſt, in as much as it appears, that the cellular membrane certainly conſtitutes the groundwork

work of the ſtructure of the whole body, if we figure to ourſelves the entire removal of every other ſubſtance which enters into, and aſſiſts in completing, the compoſition of the ſyſtem, the cellular membrane, ſtill remaining in its proper ſituation, unmoleſted and alone, will nevertheleſs preſerve and exhibit the complete figure of the whole and every part of the body.

Secondly, as by means of this cellular foundation, a certain connection and medium of communication are formed, between all the parts of the body, however widely different from each other they may be, in nature, or remote, in ſituation; the knowledge of this fact ſerves an important end, not only in deciding controverſies which reſpect the continuation of membranes, but alſo in explaining many phenomena of diſeaſes which daily preſent themſelves.

§ 32.

As the cellular membrane appears thus to afford origin and foundation to moſt of the ſolid parts of the body, ſo it appears itſelf to owe its own exiſtence to the lymphatic part of the blood, of which we have already ſpoken. I am induced to entertain this opinion from having ſeen the lymph, after tranſuding from the lungs of pleuritic patients, converted by the powers of the animal economy

into real cellular ſubſtance, which afterwards aſſuming the appearance of more compacted membranes, oftentimes attaches thoſe viſcera to the ſurrounding pleura.

§ 33.

What has been already advanced on the ſubject, may be ſufficient to ſhow the general nature, and eſtabliſh the importance, of the cellular membrane. We will now proceed to conſider ſome of its varieties.

And, in the firſt place, its firmneſs is not always uniform.

For, in general, other circumſtances being alike, the cellular membrane of the human body is very tender indeed, when compared with that of other animals. If I am not deceived, this very ſoftneſs and pliancy of the cellular ſubſtance in the human ſyſtem, deſerves to be ranked among the leading prerogatives of man; becauſe, in conſequence of it, his ſuſceptibility of impreſſions from the more refined and ſubtle ſtimuli is greatly increaſed, as well as his capacity to perform motions and various functions, with facility and perfection.

But with regard to the more lax or firm texture of the cellular membrane, even among mankind themſelves,

themſelves, a very great variety occurs, depending on age, ſex, mode of life, climate, &c.

Finally, the condition of this membrane as to denſity and firmneſs, is various, as it is found exiſting in different parts of the ſame body: thus, it is more lax on the eye-lids and prepuce, more compact and firm about the ears, &c.

§ 34.

We now proceed to conſider another uſe or office of the cellular membrane, beſides that which we have already ſaid it performs to the body in general, (§ 29, 30); namely, that by means of its numerous ſmall cells, it affords convenient temporary receptacles for fluids of different kinds.

That fluid, which thoſe minute cells are more particularly deſtined to receive, is a fine halitus of a ſerous nature, or a very ſubtle water, by which almoſt all parts of the body are moiſtened, and lubricated, and which this cellular web appears to abſorb, after the manner of a ſponge *.

* If it be admiſſible to deſignate by the name of *veſſels*, thoſe *minute interſtices* of the cellular membrane, by which it abſorbs fluids after the manner of a ſponge, I readily acquieſce in the opinion of William Hunter, (ſee Medic. Obſ.

§ 35.

But, befides this, the cellular membrane, in certain parts of the body, ferves as a refervoir to humours of a different and fomewhat fpecific nature. Thus, that portion of it which conftitutes the vitreous fubftance of the eye, is charged with a fluid of the fame name:

That which forms the meddullary membrane of the bones (commonly, though improperly, called the internal periofteum) contains the medulla: and,

Finally, A large portion interwoven through the foft parts of the body, furnifhes a convenient receptacle for the other portions of oily fubftance.

Obf. and Inquiries, vol. ii. p. 27. feq.) that this web-like expanfion, now under immediate confideration, is compofed of a congeries of veffels, in like manner with the other parts of the body. But if he entertained a belief, that this membrane confifts of fmall *cylindrical veins*, which anatomifts commonly mean to reprefent by the term *veffels*, I muft acknowledge, that microfcopical obfervations, conducted with the utmoft degree of minutenefs, and the moft cautious circumfpection, have not been fufficient to furnifh me with any unequivocal teftimony that fuch veffels actually exift, but have rather induced me to embrace a contrary opinion.

§ 36.

§ 36.

And here indeed a threefold variety presents itself to our consideration:

There are, in the first place, certain parts of the body, the cellular substance of which, though of a very soft and extremely flaccid nature, is notwithstanding, never filled with fat in a healthy subject; such, for instance is that which lines the eyelids, and that spread on the genital organs of the male, &c. But further, in numerous parts throughout the body, there are not unfrequently found irregular and transient collections of fat, which appear to reside in the same kind of cells, which at other times act as reservoirs to the attenuated serous fluid already mentioned.

But finally, in certain parts of the body, and, unless I am deceived, in cells of a peculiar nature, and given description, fat is found constantly enclosed, designed to subserve stated, uniform, and specific uses in the animal economy, such, for example, is that which, in the female system, forms the *mons veneris*, which appears to me to constitute a very peculiar and completely circumscribed protuberance *.

* This circumstance I had an opportunity of ascertaining in a much more satisfactory manner in the dead body of a female ape. After having for some time subjected the corpse to the action of cold, I was able, by removing the skin, to

expose

§ 37.

On the ſubject of the fat itſelf we will now proceed to make a few obſervations, this being ſo very proper a place for entering on the conſideration of it.

It is an oil, not unlike the unctuous oils of vegetables; bland, inodorous, and lighter than water, conſiſting of phlogiſton, united to phlegm by means of an acid of a peculiar nature.

§ 38.

It is formed at ſo late a period in the fœtus, that ſcarcely an indubitable veſtage of it can be diſcovered earlier than the fifth month after conception.

Its conſiſtence is various in different parts of the body. That for inſtance which lines the inſide of the orbit of the eye, is more fluid, whilſt that on the contrary which ſurrounds the kidneys approaches to the firmneſs and appearance of ſuet.

§ 39.

A controverſy has exiſted with reſpect to the *ſecretion* of this ſubſtance, namely, whether it is performed by a peculiar ſet of glandular bodies,

expoſe entire the circumſcribed globe of fat ſituated beneath the pubes.

agreeably

agreeably to the opinion of William Hunter, or whether it merely tranfudes, by fimple diapedefis, through the patulous mouths of arteries? The latter of thefe opinions, befides other arguments which might be advanced in its favour, appears the moft probable from hence, that not unfrequently preternatural collections of fat have been difcovered in other parts than thofe commonly occupied by this fubftance: this circumftance can be much more aptly and rationally explained by attributing fuch unufual collections of fat to an *error-loci*, arifing from a morbid ftate or difpofition of the veffels, than by referring it to an unnatural and recently formed fyftem of glands: thus for example, in the very ball of the eye itfelf, fat has been fometimes found; and a fubftance of a nature like fuet, ufually fills up the cavity from which a tefticle has been extracted; indeed there fcarcely exifts a cavity in the body in which fteatomatous collections have not made their appearance.

But to conclude; thofe fmall glands to which certain celebrated characters have been folicitous to attribute the fecretion of fat, appear as yet to be in reality nothing more than mere creatures of analogy.

But

But however this may be determined, it is in the mean time very certain, that both the ſecretion and abſorption of this ſubſtance can be performed with the utmoſt diſpatch.

§ 40.

The uſes of the fat are numerous. It lubricates the ſolids, and thus facilitates motion. It obviates and prevents a morbid exceſs of ſenſibility. It acts as a defence againſt cold: and, finally, by its uniform diſtention of the ſkin, contributes to comelineſs and beauty. Not to mention the peculiar uſes of the fatty matter conſtantly beſtowed on certain parts of the body, as the medulla of the bones, &c.

This ſubſtance appears, however, to contribute ſcarcely any thing to the nouriſhment of the human ſpecies *, when in the enjoyment of entire health.

* That bloodleſs inſects, however, derive a principal part of their nouriſhment from the fatty ſubſtance with which their bodies are plentifully ſupplied, is a conjecture of naturaliſts founded at leaſt on probability.

SECT.

SECT. IV.

OF THE VITAL ENERGIES IN GENERAL, BUT PARTICULARLY OF CONTRACTILITY.

§ 41.

WE enter now on the confideration of a difficult fubject, namely, *the living folid*, and fhall attempt a full account of the vital energies, by which the different parts of our body appear to be animated and fitted, as well to receive the impulfe of ftimuli, as to perform the various motions which are neceffary in the economy of the living fyftem.

§ 42.

But with refpect to the *living folid*, it will firft be neceffary to afcertain its exact limits, and to define it with precifion and accuracy; whence it will evidently appear, that it is not our intention, on the prefent occafion, to treat either of *thofe properties*, which the human body poffeffes in common with numerous other bodies in nature, fuch as *elafticity* (the powers of which, however, are notwithftanding exhibited in various motions and functions of the animal economy), nor yet of *thofe* which refide exclufively in the *mind*; tho' we flatter ourfelves no one will deny the powerful influence of thefe latter over the energies poffeff-

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ed by the living ſolid itſelf, conſidered as a material body. We will confine ourſelves ſolely to the conſideration of thoſe energies which reſide in our body as a ſyſtem of organiſed matter, and which appear to be related to each other in the following order.

§ 43.

The firſt and moſt univerſal ſpecies of thoſe vital energies, and which may indeed be regarded as an inferior degree of the others, or rather as the threſhold leading to them, is ſimple *contractility*, i. e. a propenſity in a part to contract itſelf. As this property appears in reality to reſide in every part of the cellular membrane, it muſt be equally extenſive with that membrane itſelf, and therefore may be ſaid to pervade almoſt the whole body. Hence this may be called, with perhaps ſufficient propriety, the *vis celluloſa*.

§ 44.

Another of the vital energies is, the *irritability of Haller*, which reſides in muſcular fibres only, and may therefore be called the *vis muſcularis*. It manifeſts itſelf by a very ſingular, oſcillatory and tremulous motion, eaſily diſtinguiſhed from ſimple contraction, by its being more readily excited to action on the application of any acrid ſtimulus.

§ 45.

The third is *fenfibility*, which refides folely in the nervous medulla, communicating with the fenforium, called therefore *vis nervea;* when any part endowed with this property is acted on by irritating ftimuli, an impreffion is immediately made on the fenforium.

§ 46.

The three foregoing may be, with propriety, confidered as *common* or *general* vital energies; becaufe they exift, more or lefs, in almoft all, or at leaft in a great many, parts of the body, which the ancients called therefore *fimilares*, *i. e.* parts of a fimilar nature.

§ 47.

But befides the foregoing, there exifts alfo a fourth energy worthy of our confideration, namely, the *vita propria*, or *fpecific life;* under which denomination I mean to arrange fuch powers as belong to certain particular parts of the body, deftined for the performance of peculiar functions, and which cannot with any propriety be referred to either of the claffes of *common energies*, formerly mentioned.

Inferring fynthetically, or *a priori*, as it is termed, it is not repugnant to found induction to conclude, that parts differing from all others in

texture, in arrangement, and in peculiarity of function, muſt alſo be furniſhed by nature with peculiar properties and powers, adapted to the performance of ſuch ſpecific action.

But reaſoning analytically, or *a poſteriori*, we are likewiſe taught by accurate obſervations made on nature herſelf, that there are certain parts of the body, particularly ſome of the viſcera, which perform motions ſo very ſingular, as cannot by any means be ſuppoſed to ariſe from either one or other of the common energies, of which we have already ſpoken, but muſt be referred to a *vita propria*, or ſpecific energies of their own.

Inſtances of ſuch ſigularity of action we have in the motions of the iris; the erection of the papilla in the breaſts of females; the motions of the fimbriæ of the fallopian tubes; the action of the placenta; the action of the uterus in parturition; the deſcent of the teſtes in the male fœtus; and, if I am not deceived, in a great part, if not in the whole of the proceſs of ſecretion.

§ 48.

The fifth and laſt energy which claims our attention is, the *niſus formativus*, or formative propenſity, which ſhould be conſidered as the efficient cauſe of the whole proceſs of *generation* (taken in

ſo

ſo extenſive a latitude as to include both *nutrition* and *re-production* as modifications of itſelf). In conſequence of this propenſity, the matter of the animal ſyſtem, whether appropriated to generation or nutrition, being lodged in the places deſtined for its reception, and having acquired ſufficient aſſimilation and maturity, aſſumes forthwith its due arrangement and figure, and enters into the compoſition of thoſe parts which are afterwards furniſhed and enlivened either with the whole or part of the energies we have already enumerated, viz. *contractility*, *irritability*, *ſenſibility*, or finally *ſpecific life*.

§ 49.

Of this *niſus formativus*, or formative propenſity, more will be ſaid when we come to treat of the proceſs of generation.

Irritability will be more fully conſidered when on the ſubject of *muſcular motion*.

The ſubject of *ſenſibility* will be again reſumed when we come to conſider the action of the nervous ſyſtem.

Of the *vita propria*, or ſpecific life, we will every where treat, when the ſubject under conſideration may render it proper.

But with refpect to *contractility*, the prefent is a very fuitable place to offer on it a few additional and particular obfervations.

§ 50.

I have already faid that this energy pervades almoft the whole body, at leaft, that its extent is commenfurate with the extent of the cellular membrane.

In the firft place, therefore, it refides in all fuch parts as confift of compacted cellular fubftance, of which the different membranes of the body ferve as examples. That thefe poffefs contractility will not be denied by any one who reflects on the conftriction of the *dartos tunic*, or who calls to mind the fpafms of the fkin, or of the peritoneum, which alone appears fometimes to incarcerate and ftrangle the inteftines in cafes of hernia.

Further, It alfo exifts in fuch vifcera as are compofed chiefly of this kind of membrane; of this defcription are the lungs, the external fuperficies of which is highly contractile, as I have lately learned from frequently puncturing and irritating them in a living ftate; but I have not found them poffeffed of any real irritability, as has been lately afferted by Varnier.

Even

Even the bones themſelves do not appear to be entirely deſtitute of contractility, as we learn, not only from the alveoli, which are well known to become narrower after the extraction or loſs of the teeth, but alſo from the morbid affection termed *necroſis* (*i. e.* mortification), from which it appears, that after a lifeleſs part of bone is quite removed, the new production of bone, by which the vitiated part was before ſurrounded, contracts itſelf very gradually, almoſt to the natural thickneſs and former figure of the part.

But as we obſerved on a former occaſion, that the vitreous ſubſtance of the teeth was quite deſtitute of cellular membrane, ſo it appears to me probable, that it is entirely deſtitute of contractility alſo, becauſe, when a part of it is either conſumed by a caries, or broken off by accident, the remaining portions or ſides are not approximated to each other, as we have already ſaid takes place in the alveoli, but an irreparable hiatus or chaſm continues without a ſhadow of diminution.

§ 51.

This very power of contraction, poſſeſſed by the cellular membrane, ſhould be ranked among the primary and leading ſecurities or ſupports of firmneſs and health ; and to it ſhould be referred that *tone* of parts, ſo highly and favourably ſpoken of

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by the acute and ingenious Stahl. To advance one argument in favour of the foregoing poſition, from many which might be adduced, it is the cellular ſubſtance which, in a healthy ſubject, abſorbs, after the manner of a ſponge the aqueous liquid, of which we have already ſpoken, and by means of its contractility propels it forward into the lymphatic veſſels: on the contrary, in a diſeaſed ſtate, being deprived of its proper tone, and reduced to an atonic condition, it becomes oppreſſed and diſtended with a load of water, and thus gives riſe to œdema and other cachectic ſymptoms.

§ 52.

Finally, from the univerſal prevalence of contractility throughout the whole body, we may plainly infer its influence and contagious effect, as it were, on the other vital energies; and alſo from its infinitude of modifications and degrees in different men, we learn its highly influential part in the conſtitution of both the proper health and peculiar temperament of each individual.

SECT.

SECT. V.

OF SOUND HEALTH, AND OF THE NATURE OF MAN.

§ 53.

THOSE three ſubjects (§ 1.) in the conſideration of which we have been hitherto engaged, perpetually act and re-act on each other in the living human body. The fluids, for example, act by their ſtimulus on the ſolids; while theſe again, in conſequence of their vital energy, are fitted and prepared both to receive the action of the ſtimulating fluids, and to re-act on them in turn. In a ſound and healthy ſubject, this whole routine of action and re-action, correſponds with ſuch exactneſs and definitude, as to conſtitute a perfect and harmonious *equilibrium*.

§ 54.

There further exiſts in the living ſyſtem a wonderful conſent of parts, even the moſt remote; this conſent is derived not from one, but ſeems to owe its origin to different ſources.

One of thoſe ſources reſides in the nerves, depending as well on the aſtoniſhing net-like anaſtomoſes, formed by their numerous branches, as on the intricate nature of their *plexus* and *ganglia*;

by the medium of which, the impulſe of ſtimuli being communicated to the ſenſorium, may from thence re-act on parts more remote.

Another ſource of this wonderful conſent muſt be referred to the different veſſels of the ſyſtem, as well the ſanguiferous as the lymphatic.

Another, again, ariſes from a certain ſimilitude of ſtructure, giving origin to what may be called a native ſympathy.

The cellular membrane, which, as has been already obſerved, appears to conſtitute a common bond of union to the whole body, may be readily conceived to poſſeſs a very ſtriking and powerful influence in promoting the conſent of diſtant parts.

§ 55.

Finally, to this head belongs what is juſtly eſteemed one of the greateſt myſteries of nature, namely, the connection of the mind with the body, and the diverſified and aſtoniſhing power of the one over the other. As this ſubject will be again reſumed, and treated more fully in another place, it will be ſufficient on the preſent occaſion briefly to obſerve, that beſides the obvious power of the *will* over moſt of the muſcles, there are alſo *other faculties* which exert their influence on the

the body, even without the concurrence or aid of the will.

Of this defcription are thofe blind and purely animal inftincts of our nature; fuch, for example, as that which excites to the gratification of venereal enjoyments.

Further, the body is greatly under the influence of the *internal fenfes*, more efpecially of the *imagination*, and thofe paffions of the mind which it contributes to excite.

Finally, it is by the interpofition, and through the medium of thefe, that a communication and reciprocal influence are preferved between the powers of the body, and the more exalted faculties of the mind.

§ 56.

By this diverfified confent of the folids, of the fluids, and of the vital energies (§ 53.), by this fympathy of parts (§ 54.), and by this intimate connection between the mind and the body, (§ 55.), *life* and *health* are preferved in vigour; yet not always exifting in the fame, but in widely different degrees of perfection and energy.

§ 57.

§ 57.

Between the two extremes of *life* there exist different grades, of which one is called *vita maxima*, or perfect life; the other *vita minima*, or imperfect life.

Life is said to be *perfect* in the flower of age, when the functions of the body have reached that pinnacle of perfection, called by the Greeks *acme;* this might also be denominated the *athletic state.*

Life, on the other hand, is said to be *imperfect* when the functions are performed with less vigour; although their perfection may be the most consummate, when the situation of the subject, and its mode of existence, are taken into consideration: thus life is imperfect in a *fœtus in utero*, and that in proportion as the fœtus is tender and young. Finally, life is less perfect in the *sleeping* than in the *waking* state; less perfect also in a subject advanced in years, than in one basking in the meridian blaze of manhood.

§ 58.

The varieties in point of *health* are no less numerous and considerable: there is indeed a certain state of health which may be said to be peculiar to each individual. Such persons as we sup-

pose

pofe to be in the enjoyment of the moft complete health, differ, notwithftanding furprifingly from each other, as well in confequence of a difference in the conftitution of the blood, as of a diverfity of tone, and of the other vital energies; hence different individuals are fo differently affected by the fame ftimuli acting on their bodies. Perhaps each individual may poffefs peculiar idiofyncrafies, though fo very inconfiderable as to be fcarcely obfervable: the influence of cuftom is fo powerful, as to create, in different fubjects, an intolerance of different impreffions, though in themfelves quite innocent; it alfo produces a facility of bearing, and finally creates a defire for, fuch things as appeared at firft both unnatural and difagreeable.

§ 59.

This appears to be the very hinge on which revolves the nature and variety of *temperaments*, fo frequently the fubjects of phyfiological difcufion. The conftitution of the temperaments depends, not only on the proportion and mixture of the conftituent parts of the blood (§ 22.), but alfo on the peculiar vigour of the vital energies already treated of; and likewife on the confequent variety in the mode of the reciprocal action and re-action of the body and mind on each other. From this combination and concurrence arifes that peculiarity

rity of ſenſation to the impreſſions of ſtimuli ; and alſo that ſingular power of performing motions with greater or leſs facility.

§ 60.

Hence the varieties of temperaments are literally infinite, and can never be reduced to any certain and definite claſſes. But as it has been the pleaſure of phyſiologiſts to arrange them under certain heads, for the ſake of regularity, we may with ſufficient propriety give our aſſent to the common mode of arrangement, by which they have been reduced to four *orders*, namely, the phlegmatic, the ſanguineous, the choleric, and the melancholic.

§ 61.

For although Galen erected this diviſion on an abſurd foundation, falſely ſuppoſed to be derived from the nature and conſtituent parts of the blood, yet if this erroneous foundation be kept entirely out of view, the diviſion appears in other reſpects ſo conſonant to nature, that the different temperaments of all men generally, and of every individual in the different periods of life, may be with propriety referred to one or other of theſe four leading claſſes. Thus, in the tender age of infancy the *phlegmatic* temperament chiefly prevails. This in youth is exchanged for the *ſanguineous.*

guineous. The *choleric* marks the period of manhood. And the *melancholic* is the temperament of old age.

But, as has been already obſerved, the variety in the exiſting degrees of the ſame, and in the mixtures of different temperaments, is ſo unbounded, as to afford an open and a very extenſive field of ſpeculation to ſuch as would wiſh to amuſe themſelves with tracing out, and eſtabliſhing, on this ſubject, more minute combinations, or diviſions and orders.

§ 62.

This whole collective aſſemblage of all the faculties and laws hitherto mentioned, by which the functions of the human body are performed and regulated from the opening, to the cloſing pulſe of life, are called *human nature*, or the *nature of man;* from whence aroſe the name of *phyſiology*, the *ſcience* now under our immediate conſideration.

§ 63.

Thoſe functions of the body may be themſelves properly enough divided into four claſſes; which diviſion, although not entirely free from exception, nor perfectly conformable to nature, may nevertheleſs be aptly enough retained as a uſeful aſſiſtant to the memory.

I. The

I. The firſt claſs of this diviſion embraces the *vital functions*, ſo called becauſe their inceſſant and unmoleſted action, is more eſpecially and eſſentially neceſſary to the continuance of life. To this claſs belong the *circulation* of the blood, and after birth the proceſs of *reſpiration*.

II. The ſecond claſs embraces the *animal functions;* theſe ſerve to diſtinguiſh *animals* from organiſed bodies belonging to the vegetable kingdom *. This claſs in man includes the connection

* I lament it as a ſerious misfortune to the ſcience of *natural hiſtory*, that his final object did not call on the very learned and ingenious profeſſor to be more explicit and minute on that claſs of functions denominated *the animal*. He has told us in terms very general and definite, that they are ſuch as ſerve to conſtitute the great barrier of diſtinction between animal and vegetable bodies. I am ſorry that neither the object nor extent of an elementary work permitted him to deſcend to a more minute ſpecification of thoſe characteriſtics, in which the difference between animals and vegetables more immediately conſiſts. *Few* points of inveſtigation can be propoſed which have given riſe to a greater diverſity of opinion, than that which reſpects the difference between theſe two claſſes of natural bodies ; and *fewer* ſtill perhaps can be advanced, with regard to which philoſophers, even in the preſent imperfect ſtate of phyſical ſcience, ſhould more unanimouſly agree. Be this later poſition, however, true or falſe, I have always been led to conſider the ſtrangely diverſified, and even contradictory opinions, entertained by naturaliſts reſpecting the difference between animals and vegetables, as ſo

of the mind with the body, but it regards more eſpecially ſenſation, and muſcular motion.

ſo many unanſwerable teſtimonies of the equivocality of the whole. The diſcovery therefore of an excluſive line of diſtinction between the animal and vegetable kingdoms, (if indeed the ſupreme author and arbiter of nature permits ſuch a line to exiſt) muſt ſtill be conſidered as a peculiar *deſideratum* in the ſcience of natural hiſtory.

From all my ſpeculations on this intereſting ſubject (and it is with me a favourite object of purſuit) I am firmly of opinion, that there exiſts no incommunicable characteriſtic, and I will venture to add, no congregation of characteriſtics, which ſerve to conſtitute a complete partition-veil between the animal and vegetable kingdoms. The numerous and highly diverſified ſubjects of theſe two important kingdoms of life, appear to be nothing elſe than different individuals of one extenſive family, deſcended from a common parent, and exhibiting the moſt unequivocal teſtimonies of their kindred nature. Like the delicate tints of light and ſhade in a well finiſhed picture, they ſo gradually intermingle, and run into each other ſo inſenſibly, that it is literally impoſſible to ſay with definitude, where the one terminates and the other begins

All reſearches therefore after an excluſively diſtinctive characteriſtic between vegetables and animals, appear to me equally irrational and viſionary with the late enthuſiaſtic purſuits of the deluded alchemiſts, after the philoſopher's ſtone, or their more chimerical reſearches after their flattering *panacea*. Why then ſhould man, preſumptuous man! attempt the eſtabliſhment of an eſſential diſtinction between phyſical bodies, where wiſer *nature* acknowledges none!

III. The *natural functions* conſtitute the third claſs. Theſe are ſubſervient to the nouriſhment of the body.

IV. The fourth and laſt claſs conſiſts of the *genital functions*, which are deſtined for, and employed in the propagation of the ſpecies.

Let us now conſider each claſs of functions in order, beginning with the *vital*.

SECT. VI.

OF THE MOTION OF THE BLOOD IN GENERAL.

§ 64.

THE blood as we have already ſeen, affords the primary origin to the principal parts of the body, and continues afterwards to convey to them uniform and perpetual ſupplies of nouriſhment, and ought therefore, with a very few exceptions (§ 5.) to be diſtributed far and wide, through even the moſt ſubtle and diſtant receſſes of the whole body. That ſuch a minute diſtribution actually takes place, we learn not only from a fine injection of the veſſels, but alſo from every day's experience, from which it appears that very

ſew parts of the body can be punctured with the point of the ſmalleſt pin without the occurrence of a greater or leſs hemorrhagy.

§ 65.

This vital liquid does not, as was the opinion of the ancients, flow and ebb like the waves of Euripus *, through channels of the ſame nature and order, but is ſo moved onward in an orbit, or *circulates*, as they expreſs it, in ſuch a manner, as to be carried from the heart, by means of the arteries, to every part of the body; and being there taken up by the veins, conveyed back again by them to the ſame original fountain, *the heart*.

§ 66.

After a few, and thoſe very indefinite, expreſſions † of his predeceſſors, William Harvey eſta-

* A narrow arm of the ſea, extending between Bœotia and Eubœa, ſaid to ebb and flow ſeven times during each diurnal revolution of the earth, or each term of 24 hours. In this extraordinary portion of ſea, Ariſtotle, that celebrated ancient philoſopher, is falſely reported to have drowned himſelf, becauſe he was not able to develope the cauſe of the conſtant flux and reflux of its waters. C. C.

† The unfortunate *Servetus*, and that truly illuſtrious character *Andr. Cæſalpinus*, appear to have advanced nearer to a true knowledge of the genuine circulation of the blood, than any of the other phyſiological writers who are commonly enumerated in the ſame claſs.

bliſhed, in a manner tolerably concluſive, the circulation of the blood, in a ſmall but immortal work publiſhed in the year 1628.

In proceſs of time, however, every ſhadow of doubt on this ſubject was removed. This was effected *chiefly* by frequent recourſe to actual and ſimple obſervations with the microſcope; but *in part* alſo by injections of wax and other ſubſtances into the arteries, which were ſeen paſſing again to the heart by the route of the veins; and, further, by the elegant and ſublime experiment of

It may not be improper on the preſent occaſion to advert to a remarkable clauſe in the writings of Servetus, contained in a phyſiological diſſertation, which he included in his celebrated and very ſcarce work, that occaſioned the death of its illuſtrious author. The work is entitled "Reſtitutio Chriſtianiſmi," &c. (Viennæ Allobrog.) 1553-8. The diſſertation particularly alluded to, is contained in the fifth book of the abovementioned work, "*de trinitate divina, in quo agitur de ſpiritu ſancto,*" in which we are preſented with the following words, "*Vitalis eſt ſpiritus qui per anaſtomoſes ab arteriis communicatur venis, in quibus dicitur naturalis.*"

But from the memorable problem of Cœſalpinus, "*de venis ultra vinculum tumeſcentibus, non citra,*" it appears obvious as the blaze of day, that that truly illuſtrious phyſiologiſt trod on the very confines of a complete knowledge of the circulation of the blood. See his "Quæſtionum medicatum," L. II. quæſt. 17. page 234.

transfuſing

transfufing the blood of one living animal into another, or into a human fubject; as alfo by various other experiments which may be performed on animals in a living ftate.

§ 67.

What fhould be efteemed the definite ftandard of the celerity of this motion, in a healthy human fubject, we are not well able to determine. In this refpect there is not only a difference between one fubject and another, but there alfo occurs a great variety relating to this point, arifing from the difference of ages: there indeed exifts a difference in the celerity of the blood's motion, even in the different parts of the fame body.

Finally, the venous blood appears to glide on more flowly than the arterial; and when flowing through the *trunks* of veffels, its motion is more rapid than when paffing their fmaller ramifications. Former phyfiologifts, however, have notwithftanding exaggerated thefe feveral diverfities, in the celerity of the blood's motion, beyond their natural magnitude.

The common conclufion, however, on this fubject is, that the blood, flowing through the aorta with its mean velocity, paffes over a diftance of about eight inches during the fpace of one pulfa-

tion; at which rate it would travel about fifty feet in the firſt minute of time.

§ 68.

The globules of the cruor appear to revolve on their axes or centres of motion; and it is ſaid that the ſame are propelled forward with greater velocity than the other conſtituent parts of the blood. I know not whether this concluſion be drawn from actual experiment, or whether it be only an inference from an abſurd application of the common laws of hydraulics to the circulation of the blood: I call the application abſurd, becauſe it is certainly the very ſummit of folly, to attempt to account for that motion of a vital fluid, by which it is carried through the living canals of an animated ſyſtem, on the purely mechanical principles by which water is forced through hydraulic machines.—As to myſelf, I muſt acknowledge I have never been ſo fortunate as to be favoured with a view of this *prerogaitve* or preceſſion of the globules.

§ 69.

I am fully perſuaded, that thoſe globules only glide forward, ſuſpended or ſwimming in the fluid formed by the other conſtituent parts of the blood, but that they do not at the ſame time rotate on their own axes at all. To conclude, it is not fully

fully and clearly aſcertained, that the blood, beſides its *progreſſive* motion, of which we are now ſpeaking, is alſo ſubjected to one of a different kind, called an *inteſtine* motion; although there can be no doubt, but that the elementary parts of the blood may be occaſionally affected in their arrangement and combination, when they are tumultuouſly agitated in conſequence of the immenſely varied directions, the minute diviſions and numerous anaſtomoſes of the veſſels through which they paſs.

§ 70.

Thus much we thought proper to advance on the motion of the blood in general. Previouſly to our entering on a more cloſe and minute conſideration of this ſubject, we think it beſt to treat of the veſſels in which the blood is contained, and alſo to conſider with attention the energies, by which theſe veſſels are animated, and fitted both to receive and again propel the blood.

SECT. VII.

OF THE ARTERIES.

§ 71.

THE veſſels which receive the blood immediately from the heart, and convey it to all the different and minute parts of the body, are called *arteries*.

In their collective or aggregate dimenſions, they are leſs capacious than the *veins;* but their texture is far more ſolid, more compact, very elaſtic, and, as appears, from the experiments of Wintringham, remarkably ſtrong.

§ 72.

They are compoſed of three membranous ſtrata, or coats.

I. Of an *external*, which Haller called a true *cellular* coat, Albinus a *nervous*, Veſalius a *cartilaginous*, others a *tendinous*, &c. It conſiſts of condenſed cellular membrane, externally more lax, but becoming by degrees more compact, as you advance nearer to its internal ſurface, where it is overſpread with numerous ſmall blood veſſels.

To

To this coat the artery appears to be chiefly indebted for its tone and elasticity.

II. The second or middle stratum, is composed of transverse fibres, assuming a lunated or falciform figure and direction; its substance has a fleshy appearance, from whence it has been called the muscular coat, and in it the vital energy of the arteries appears in a very particular manner, to reside.

III. The last and most internal coat, is a membrane of an extremely smooth and polished surface, which serves as a lining to the cavity of the artery.

In the trunks and larger branches of the arteries, these coats may be distinctly observed; but they are less evident in the more minute ramifications.

§ 73.

All the arterial branches in the human body take their origin from either one or the other of two leading trunks.

The *first* of these trunks is the *pulmonary* artery, which, rising from the anterior ventricle of the heart, passes into the lungs.

The *ſecond* is the *aorta*, which riſes from the poſterior ventricle of the heart, and ſhoots its ramifications into every part of the ſyſtem.

Theſe trunks are divided into branches, which again undergo farther and more minute ſubdiviſions.

§ 74.

An opinion has been conceived and propagated as an eſtabliſhed truth, that, throughout the whole ſanguiferous ſyſtem, the *aggregate capacity* of all the branches, taken together, is ſuperior to that of the trunk from which ſuch branches directly originate. I fear, however, that the authors of this opinion have expreſſed themſelves on this ſubject in terms by far too general, and have ſometimes even confounded the meaſure of the diameter of veſſels, with that of their area. In my inveſtigations and inquiries on this ſubject, I did not truſt to the reſult of a ſingle experiment, nor did I confine my experiments to veſſels filled with wax, which, however improper, were the only kind uſed by ſome celebrated phyſiologiſts, in their attempts to aſcertain the matter now under conſideration; but, as the nature and importance of the ſubject evidently demanded, I made my experiments and obſervations on the ſound and unaltered veſſels of ſubjects recently dead. I took, for

for example, that namelefs trunk from which the right carotid and fubclavian arteries diverge as branches, and alfo the brachial trunk, together with its branches, the radial and cubital arteries, and having formed a rectangular triangle, from the diameter of the trunk and the diameters of its appended ramifications, I found, from the well known theorem of Pythagoras, that the fquare of the hypothenufe was equal to the fum of the fquares of the bafe and perpendicular.

Indeed, in arteries of the fmalleft orders, Haller himfelf acknowledged that the capacity of the trunks is greater than that of their ramifications; fo that, at leaft, the common calculation does not apply univerfally, but, (if it be indeed ever admiffible), muft be reftricted to a very few orders of veffels.

§ 75.

Each trunk and ramification, feparately confidered, have been commonly believed to poffefs a conical figure, the bafe, or that part next to the heart, being fuppofed more capacious than the oppofite extremity. This opinion appears however to be hypothetical: for, whoever will take the trouble of examining the arteries with accuracy and attention, will find their figure to be perfectly cylindrical: indeed, on the other hand, there

there are not wanting inftances of fome arteries which in their progrefs rather widen and expand, fuch, for example, are the mammariæ internæ, or internal mammaries, and even the arch of the aorta itfelf is more contracted at its bafe than at its apex or top. All arteries, efpecially thofe of the larger orders, appear to be a little dilated and enlarged, juft before their divifion into branches.

§ 76.

The number of orders, formed by the divifions of the main arterial trunk into the progreffive feries of uniformly decreafing ramifications, from its firft origin at the heart, to its final termination in the extreme capillaries, cannot poffibly be univerfally afcertained and eftablifhed as a general and unvarying refult. The truth of this pofition will be obvious to any one who confiders, that in the different parts of the body, efpecially in the vifcera, the arteries are fubject to great variety with refpect to their divifions; and that, on this account, they fometimes form more, fometimes fewer orders of veffels, previoufly to their feparation into evanefcent capillaries.

Hence the difagreement of authors who have attempted to amufe themfelves with calculations of this kind. Thus, for example, Keil eftimated the number of the orders of arteries at fifty, while Haller

Haller contended that they amount to no more than twenty.

§ 77.

After numerous divifions of this kind, and various anaftomofes, by which the neighbouring branches of arteries communicate with each other, they at length arrive at their final terminations, which are completely continuous with, or which fairly open into, the origins of *veins*; fo that, their route being uninterrupted, they are reflected from extremities that can fcarcely be difcerned, and thus converted into thofe returning veffels, by which the blood, lately arterial, but now become venous, is conveyed back again to the heart.

§ 78.

But although this complete continuity of the arteries and veins be fo extremely evident in numerous parts of the body, as to be obvious even to the naked eye, yet it ftill remains a matter of doubt, whether this be the only and exclufive mode, in which arteries communicate with veins, or whether there may not be, at leaft in certain parts of the fyftem, an intermediate and parenchymatous fubftance, which receives the blood from the terminations of the arteries, and again depofits it in the incipient mouths of the veins?

There

There occur certain phenomena, ſuch for example, as erections of the penis, and the common phenomenon of bluſhing, which render the exiſtence of ſuch a connecting medium between thoſe two kinds of veſſels, at leaſt not improbable.

§ 79.

There are, again, veſſels of a nature evidently different from thoſe already ſpoken of, which appear to ariſe every where from the ſmaller arterial branches; theſe veſſels conſiſt chiefly of two kinds, namely, *the ſerous*, which are ſo narrow as not to be able in a healthy ſubject to admit the globules of the cruor, but only to receive the thinner fluid or vehicle in which thoſe globules ſwim (§ 69.); and the *ſecretory*, which do not appear to attract any thing from the maſs of arterial blood, but ſuch ſpecific fluids as are deſtined for ſecretion (§ 4.)

§ 80.

With regard to the former kind of veſſels, which we denominated *ſerous*, it is neceſſary to obſerve, that we do not mean by them the imaginary orders of yellow and of white veſſels, ſpoken of by Boerhaave, which appear to have been fancifully conceived, in conformity to the account given by Leeuwenhoek of his equally imaginary ſixfold conformation of the globules of the blood: neither

neither do we mean the neuro-lymphatic veſſels of Vieuſſen and Ferrein, of which thoſe gentlemen ſuppoſed the viſcera to be in a great meaſure compoſed ; but which do not indeed appear to be any better founded than the preceding conjectures of Boerhaave and Leeuwenhoek.

By the *ſerous* we mean thoſe colourleſs veſſels which are never viſible, unleſs in certain caſes of violent inflammation, where the impetus of the blood is very powerful; and indeed in ſome parts of the body, even this energetic proceſs of nature is not of itſelf ſufficiently powerful to bring them into view, unleſs they be ſtill farther dilated by means of an anatomical ſyphon or injector: of this latter deſcription are, for example, the veſſels of the cornea, which can ſcarcely ever be filled with wax, unleſs in the dead bodies of ſuch ſubjects as have died while labouring under a violent inflammation of the eyes.

§ 81.

The *ſecretory* veſſels, on the other hand, appear to be different from thoſe, and belong chiefly to the ſecreting viſcera and conglomerate glands; they can alſo be traced by means of a very ſubtle injection, which, for inſtance, when thrown with force into the artery of the parotid gland, flows out and eſcapes through the duct of Stenonius. But

But on these vessels we will have a stated opportunity of being more pointed and particular in a subsequent section.

SECT. VIII.

OF THE VEINS WHICH CARRY BLOOD.

§ 82.

THAT blood, which, by means of the arteries has been distributed throughout every part of the system, must be conveyed back again to the heart through the medium of the veins.

These vessels differ very widely from the arteries, both in their functions and structure : to this, however, veins of the smallest orders form an exception, as their structure does not differ from that of arteries of the same magnitude in so wide and obvious a degree.

§ 83.

The veins (if we except the pulmonary system) are more capacious in their collective or aggregate dimensions than the arteries; their ramifications are also more numerous ; they are much more irregular in their courses and modes of ramifying ; their

their texture is alſo much ſofter than that of the arteries; they are far leſs elaſtic, but nevertheleſs extremely tenacious, and capable of wonderful expanſion.

§ 85.

Their *coats* are conſiderably thinner than thoſe of the arteries; whence the blood which they contain appears in ſome meaſure through them; they are alſo leſs numerous, being no more than a certain *cellular covering*, ſomewhat reſembling what has been called the nervous coat of the arteries, and an *internal membrane* of a very exquiſite poliſh, ſimilar to that with which the arteries are lined.

No part of the venous ſyſtem is furniſhed with muſcular fibres, except the larger trunks near the heart.

§ 86.

In by far the greater number of the larger veins, ſuch, for example, as exceed in their diameter the twelfth part of an inch, this internal membrane forms, by its foldings, an immenſe number of valves of the moſt beautiful ſtructure, exceedingly pliant or moveable, and exhibiting the appearance of ſmall ſacks: they are, for the moſt part, ſimple and alone, frequently however, ar-

ranged in pairs, and ſometimes in triplets; and are ſo ſituated and diſpoſed, that the bottom of the little ſack points to the origin of the vein, while its mouth or orifice opens, and is directed towards the heart.

Thoſe ſmall valves are, nevertheleſs, wanting in the veins of certain parts, as in thoſe of the encephalon, the lungs, &c. and in the whole ſyſtem of the vena potarum.

§ 87.

The ſmall ramifications of the veins (which would, indeed, with more propriety be called their radicles or little roots) form, by their junctions, larger branches, and theſe unite finally into ſix leading trunks; viz. the two *venæ cavæ*, one called the *ſuperior*, the other the *inferior*, and the four trunks of the pulmonary vein.

The *vena portarum* alone exhibits one phenomenon peculiar to itſelf. The trunk of that vein, on entering the liver is, after the manner of an artery, immediately divided into branches, the extreme ramifications of which become, at length, radicles to the inferior cava, and finally loſe themſelves in the boſom of that trunk.

§ 88.

We need not, on the prefent occafion, again advert to the common, and by far too general, opinion, that the areas of the branches are more capacious than the area of the trunk from which they rife, nor yet to that refpecting the conical figure of fingle veffels, as what was faid on thofe fubjects, when treating of the arteries (§ 74, 75.), will apply with fufficient precifion to the veins.

There are alfo among the veins, a few examples of veffels being more capacious at a more remote diftance from the heart; fuch, for inftance, is the *vena poplitea*, where it paffes between the condyls of the os femoris.

What has been already faid, with regard to the final terminations of the arteries (§ 77, 78, 80.), may, by making fuch obvious and neceffary changes, as are adapted to the different nature and circumftances of our fubject, be fitly applied to the origins of the veins.

SECT. IX.

OF THE HEART.

§ 89.

THERE exifts, as we have already had occafion to obferve (§ 65), a two-fold communication between the *arteries* and *veins:* one, for inftance, at the minute extremities of each kind of veffels (§ 77); and the other at the heart, their common fountain, in which the leading trunks of the whole fanguiferous fyftem meet.

§ 90.

The heart is, as it were, the firft active organ and moving fpring of the whole human machine, as it is by the perpetual and truly aftonifhing energy of this body, that the moft important vital function, namely, the circulation of the blood, is performed, from fo early a date of our exiftence, as the fourth week after conception, down to the clofing period of tranfient life.

§ 91.

This active organ, by its alternate dilatation and contraction, firft receives and again ejects the blood in the following manner. Into the anterior venous finus, and its appendage, the anterior auricle

cle of the heart, the blood is conveyed from the whole body, by means of the two *venæ cavæ*, viz. the ſuperior and inferior, and likewiſe from the ſubſtance of the heart itſelf, by means of the coronary veins, the common orifice of which is furniſhed with a valve of a peculiar ſtructure; and from this auricle, it is again conducted into the correſponding ventricle of the ſame ſide.

§ 92.

From this anterior ventricle (formerly called the *right* ventricle, in conformity to the ſituation of the heart in brutes) the blood is thrown into the lungs through the pulmonary artery, which was called by the ancients *vena arterioſa;* from thence, by the four pulmonary veins, called in former times *arteriæ venoſæ*, it is conducted into a common ſinus, formed by their conflux, and thence again into the correſponding auricle; theſe were once called the *left*, but are now more properly named the *poſterior*, ſinus and auricle.

§ 93.

From the poſterior auricle it paſſes on to the ventricle of the ſame ſide, from whence it is diſtributed, by means of the aorta, through the whole arterial ſyſtem appropriated to the other parts of the body, and by the coronary arteries, through the ſubſtance of the heart itſelf.

§ 94.

The blood having paſſed from the extreme and ultimate branches of the *arterial*, into the incipient radicles of the *venous ſyſtem*, re-enters the two venæ cavæ, (while that from the coronary arteries is alſo returned by veins of the ſame name), and thus the whole collective volume reſumes again, and inceſſantly continues, the ſame circuitous route already deſcribed.

§ 95.

This circular and regularly progreſſive motion of the blood through the cavities of the heart, is powerfully directed, and the regurgitations of that fluid are completely prevented, by means of ſmall valves, which ſurround and ſerve as portals to the principal avenues which lead to the heart. Theſe valves are ſituated on the margins, or extreme lips, of the ventricles which are adjacent to, and look towards, their correſponding ſinuſes, and alſo at the mouths of the two great arterial canals leading out of thoſe ventricles.

§ 96.

Thus a ſmall venous ring or tendon, which forms a partition between the anterior ſinus and ventricle, deſcending into the cavity of the latter, ſeparates into three ſmall valves of a tendinous appearance, each one of which was formerly believed to divide again into three apices or points, from

from whence they received the name of *valvulæ triglochines* or *tricuſpides*. Theſe valves are connected at their points to fleſhy columns, commonly called *muſculi papillares*.

§ 97.

In like manner another ſmall ring of the ſame kind, which conſtitutes a partition between the poſterior ſinus and ventricle, is alſo divided into two ſmall valves, which, from a certain ſuppoſed reſemblance to a *ſacerdotal mitre*, have been called *valvulæ mitrales*.

§ 98.

At the entrance into the pulmonary artery, as alſo at the mouth of the aorta, are ſituated, in an annular or circular poſition, three valves much ſmaller indeed than thoſe already deſcribed, but of a very elegant and beautiful figure and appearance, and furniſhed with fleſhy fibres; theſe have been called *valvulæ ſemilunares* or *ſigmoides*.

§ 99.

Now it evidently appears, that by means of theſe different kinds of ſmall valves, ſufficient proviſion is made againſt the irregular, confuſed and retrograde movement of the blood. They eaſily yield, and afford a paſſage to the blood when advancing regularly forward in the eſtabliſhed courſe

of its circulation. But they prevent the regurgitation of this fluid, by becoming, in consequence of its refluent effort, fully expanded like the swelling of a well-filled sail, and thus completely closing the orifices round which they are arranged.

§ 100.

The valve of Eustachius which, in the fœtal state, is stretched like a curtain across the mouth of the ascending cava, becomes after birth (sooner or later in different subjects) so gradually obliterated for the most part, as to be rendered wholly unfit for the execution of its former functions; neither indeed does the system stand any longer in need of it, as a passage is now opened and prepared for the blood through the lungs, and its return from those viscera prevented by the semilunar valves already spoken of, and as each subsequent column of blood, pressing from behind, must pursue the same route with that immediately preceding it. But as it does sometimes notwithstanding happen, that the passage of the blood from the right side of the heart into the lungs is by some means obstructed, we then learn from the preternatural pulsation observable in the superior cava, that the blood is repelled in a retrograde direction from the right sinus into the two adjoining great venous trunks.

§ 101.

It is a point of controverſy, whether or not the ſemilunar valves ſuffer the ventricles to be perfectly and completely evacuated, or whether they do not rather by means of their expanſion intercept a part of the blood in its eſcape from thoſe cavities, and thus force it to take in ſome meaſure a retrograde courſe.

Obſervations made on frogs, and even on the minute heart of the naſcent chick, prove that in thoſe animals the heart is indeed completely evacuated; but whether or not the ſame thing takes place in man himſelf, when in a ſound ſtate of health, is not yet clearly aſcertained; if, however, it be admiſſible, in phyſiological diſcuſſions to ſpeculate and draw concluſions from the ſtructure and mechaniſm of thoſe valves themſelves, as they appear on the diſſection of the heart, the contrary opinion appears the moſt probable.

§ 102.

The *texture* of the heart is altogether ſingular, and peculiar to that organ. It is indeed fleſhy, but remarkably cloſe and compact, and widely different from the common conſtitution and appearance of muſcles.

It is compoſed of ſmall bundles of fibres, more or leſs oblique, frequently ramifying in a ſingular manner, contorted and wound ſpirally in diverſified and truly ſtrange directions; theſe fibres lie over, and reſt on, each other in certain orders of ſtrata, they are intermingled and cloſely knit together in the ſeptum which ſeparates the two ventricles, and are faſtened and firmly connected at the baſis of thoſe ventricles by four cartalaginous rings or bands, which (according to the accurate unravelling and developement of the whole fibrous texture of the heart, lately executed by the indefatigable and illuſtrious Wolff), appear to ſerve as a ſtay and ſupport to the *fleſhy ſtructure* of the ventricles, and alſo to ſeparate and diſtinguiſh it from the fibres of the ſinuſes.

§ 103.

Thoſe fleſhy fibres are every where overſpread with an infinitude of ſmall nervous ramifications of extreme ſoftneſs, but they are more particularly ſupplied with ſuch an immenſe apparatus of blood veſſels, ariſing from, and belonging to, the coronary arteries and veins, that Ruyſch has declared in his writings, that the whole fabric of the heart appears to be compoſed ſolely of ſanguiferous tubes.

§ 104.

§ 104.

By means of the foregoing *ſtructure* (§ 90. ſeq.) and texture (§ 101. ſeq.) the heart is fitted for the performance of thoſe perpetual and uniformly equable movements, which return in ſuch general order, that the preliminary appendices and ventricles themſelves, are alternately *contracted* and *relaxed*, or perform, in alternate times, thoſe motions, called in phyſiological language, *ſyſtole* and *diaſtole*.

§ 105.

With ſuch definitude do they preſerve this harmonious order in their routine of contraction and dilatation, that as ſoon as the appendices contract themſelves, to propel the blood, returning from the lungs and venæ cavæ, into the ventricles, theſe latter are at the ſame inſtant relaxed and fitted to receive the ſame advancing wave of blood; but in the ſubſequent and next moment, when it is the point of time for the ventricles, now recently filled, to contract and force the blood into the two arterial trunks, the appendices are again relaxed, and their mouths rendered patulous for the purpoſe of drinking in a freſh tide of venous blood as it rolls on in its uſual courſe.

§ 106.

§ 106.

This ſyſtole of the ventricles, which is ſuppoſed to conſume about one third part of the whole time of the heart's pulſation, is performed in ſuch a manner, that the exterior ſides of thoſe cavities are approximated and contracted towards the intermediate ſeptum which ſeparates the right ventricle from the left; which contraction, eſpecially if we attend to the conical figure of thoſe cavities, appears fully ſufficient to evacuate them of their contents.

But beſides this approximation of the lateral parts of the heart towards each other, the apex of that organ is, during its ſyſtolic motion, contracted towards, and brought nearer to its baſis; as has been frequently obſerved not only in the inferior animals both of *cold* *, and *warm* blood, but even in man himſelf, while in a living ſtate †.

* I have not in the live-diſſection of any animal diſcovered the heart more evidently ſhortened, during its ſyſtolic motion, than in that of *coluber natrix* or water ſerpent. Throughout the foreſts in the neighbourhood of our city, this ſpecies of ſerpent may be ſometimes found four feet in length. Having taken one of theſe animals and ſubjected it in a living ſtate to the anatomic knife, I obſerved that the length of its heart during the *diaſtolic*, exceeded its length during the *ſyſtolic* motion, at leaſt the ſpace of two lines.

† It does not, however, appear that this diminution of the longitude of the heart during its ſyſtolic motion is an ab-

An argument ſeemingly in favour of a contrary opinion has been derived from, and founded in, vulgar experience, from which it appears that the apex of the heart ſtrikes, during its ſyſtolic motion, againſt the left mamma or breaſt, and ſeems therefore to be rather elongated than contracted and ſhortened; this apparently concluſive argument will however have no weight with one who conſiders, that thoſe ſenſible percuſſions or ſtrokes of the heart are to be attributed as well to the *impetus* of the venous blood ruſhing into the appendices of that organ, as to that of the arterial blood forcibly ejected from its ventricles; by both which ſources of propulſion the whole heart is carried towards and impinged againſt that region of the ribs.

§ 107.

The impetus, which is by this ſyſtolic contraction of the heart imparted to the blood, is com-

ſolute condition of life. I am led to the adoption of this opinion from a variety of obſervations made on the heart of a duck, in a great portion of which a complete oſſification had taken place. This heart was depoſited in my anatomical collection by my very liberal and worthy friend C. F. Michaelis, and is marked by completely oſſified ſtriæ running from its baſe to its apex. On its ſides, however, it was ſtill furniſhed with fleſhy ſubſtance ſufficient to continue the lateral motion of its ventricles, and thus preſerve the circulation of the blood.

municated

municated to the arterial ſyſtem, receiving the blood, in ſuch a manner, that every ſyſtole of the heart may be plainly perceived in ſuch arteries of the other parts of the body as can be felt by the touch, (of which deſcription are all thoſe that exceed in their diameters the ſixth part of a line), and likewiſe in ſuch other arteries as can by any means whatever have their pulſations rendered obvious to the ſenſes: this can be eaſily effected, for example, in the internal ear or eye, in either of which a ſingular kind of motion can be excited and rendered ſenſible, which (as well as the ſame kind of throbbing or pulſatory motion ſo perceptible in the other parts of the arterial ſyſtem) is called the *diaſtole* of the arteries: of this diaſtolic motion we ſhall have an opportunity to ſpeak on a future occaſion, at which time we will take up the inquiry, whether or not it is to be attributed ſolely to the action of the arteries themſelves, or derives its exiſtence from ſome other ſource.

§ 108.

In whatever manner this point may be determined, one thing we learn from experience, the ſureſt guide to truth, viz. that in a healthy ſubject, what is called the pulſe of the arteries, is preciſely ſynchronous with, and perfectly correſpondent to, the motions of the heart; and likewiſe in a morbid intermiſſion of the pulſe, the heart

heart and arteries ſtill harmonize in their action, by ceaſing from, and again commencing, motion at preciſely the ſame moments.

§ 109.

The frequency of the pulſations of the human heart in a healthy ſtate, is extremely different in different ſubjects. This diverſity ariſes principally from diverſity in point of age, but partially alſo from other conditions of the ſyſtem, which at any and every period of life conſtitute the health proper to each individual; ſo that it is not poſſible to aſcertain and eſtabliſh, on this ſubject, any certain and definite rule. It may nevertheleſs be proper to mention the general reſult of my obſervations (made in our own climate) on the frequency of the pulſe in the different periods of human life.

In the firſt days after birth I have generally found the pulſations of the heart of the tender infant, while found aſleep, amount to about 140 in the ſpace of a minute.

At the expiration of the firſt year, they amount to 124 in a minute.

At the end of the ſecond year to about 110.

At the end of the third year to about 96, &c.
At

At that period in which the firſt ſet of teeth, uſually called the milk-teeth, drop out, the pulſations of the heart amount to 86 in a minute.

At the age of puberty to about 80.

In the prime of life, or at the period of manhood, to about 75.

And to about 60 at the ſixtieth year of human life.

In ſubjects ſtill farther advanced in years, I have ſcarcely found two in whom the number of pulſations were the ſame, at the ſame period of old age.

§ 110.

All other circumſtances being alike, the pulſations of the heart are more frequent in females than in males.

If proper and neceſſary allowance be made for the habit of body, they are leſs frequent in men uncommonly tall, than in ſuch as are rather low. This circumſtance I have aſcertained to be a truth by comparative obſervations made on the pulſes of *dwarfs*, and *giants* or men remarkably large.

§ 111.

On the ſubject of thoſe varieties in the pulſe, occaſioned by *extraneous circumſtances*, vulgarly called *non-naturals*, it is neceſſary to obſerve, that a cold climate produces a ſlow pulſe; thus, for inſtance, the heart of a Greenlander when in perfect health, does not pulſate oftner than from thirty to forty times in a minute.

But it is an obſervation as common as it is true, that the pulſe becomes more frequent after the taking in of aliment, and after an emiſſion of ſemen. The ſame effect is alſo produced on the pulſe by a want of ſleep, by bodily exerciſe, or by paſſions of the mind.

§ 112.

The foregoing obſervations relate to the natural or healthy pulſe, in the conſideration of which it ſeems more conſiſtent, and agreeable to nature, to direct our views to the *heart*, as its excluſive ſource, than to the arteries, on which phyſiologiſts have uſually fixed their attention when engaged in the inveſtigation of this ſubject.

In this inceſſant routine, the heart continues its pulſations, down to the extreme glimmerings of life's periſhable flame; and even *then*, all its parts do not ceaſe from action at the ſame moment, but

but it is the prerogative of the right ventricle with its appendices, the right auricle and ſinous, ſurvive the left ventricle, and its appendices.

This may be ſufficiently illuſtrated in the following manner: After the laſt act of expiration, the lungs now in a collapſed ſtate, can no longer admit the blood to flow through them in its cuſtomary channel, while at the ſame time that wave of blood which they have juſt returned to the left ſide of the heart, is from thence forceably expelled through the aorta, and thus urges forward by a *vis a tergo* the advancing column of venous blood: from this combination and concurrence of circumſtances, the blood returning with precipitation and impetuoſity, ruſhes violently into the appendices and ventricle on the right ſide of the heart, in conſequence of which the parietes of thoſe cavities are thrown into convulſive efforts, and thus continue to be agitated, for ſome time, after the left ſide of that organ is completely deprived of all vital motion.

§ 113.

From a knowledge of this *fact*, viz. that during the laſt vital efforts of declining nature, the blood is propelled into the cavities on the right ſide of the heart, we deduce, with the utmoſt eaſe, the *cauſe* of that ſtate of depletion in

which the larger arteries are found after death. To the fame caufe alfo Weifs, and after him the illuftrious Sabatier, were defirous of attributing the fuperior fize of the cavities on the right, to that of thofe on the left, fide of the heart, efpecially in the corpfe of an adult fubject.

§ 114.

The whole of this motion of the heart, which has been the fubject of the preceding obfervations, is to a very confiderable degree limited and directed by the *pericardium*, in which the heart loofely hangs, and by which it is completely enclofed as in the walls of a prifon.

The pericardium is a membranous fac, confiderably capacious, and accommodated to the figure of the heart which it enclofes. It takes its origin from the membranes conftituting the mediaftinum, and although, from its finenefs, it may appear fomewhat tender, yet we learn from the experiments of Wintringham, that it is fo very tenacious and firm, as far to exceed in ftrength all other membranes of a fimilar nature in the human body.

That the pericardium is a part of the firft importance in the animal economy, we fafely infer from this fingle circumftance, namely, that throughout all claffes of animals poffeffing red blood,

blood, it is found as conſtantly and uniformly exiſting as the heart itſelf; and records do not furniſh more than one or two examples of the human heart having been found completely deſtitute of a pericardium. Theſe ſingular examples of ſuch an unnatural ſtate of the heart are recorded in the writings of Dinkler.

§ 115.

The internal ſurface of the pericardium is kept conſtantly humid by a dew-like ſerous effuſion, which appears to exhale from the ſmall arteries of the heart itſelf.

In like manner a fluid, of a ſimilar nature, appears to tranſude into the very cavities of the heart, and to moiſten and lubricate their ſurrounding *parietes* or walls.

In either caſe the effuſion during the healthy ſtate of the part is of a ſerous nature, and not accompanied by any real *lymph*, unleſs the heart be labouring under inflammation; but when this organ becomes the ſeat of an inflammatory affection, then genuine lymph tranſudes, giving riſe, on the external ſuperficies of the heart, to fine filaments of a hair-like appearance, together with thoſe preternatural portions of cellular membrane, which in ſuch caſes connect the heart to the pericardium,

pericardium, but on the interior ſurfaces of the cavities themſelves producing excreſcences of a truly polypous nature. (§ 19.)

SECT. X.

OF THE POWERS BY WHICH THE BLOOD IS KEPT IN MOTION.

§ 116.

HAVING thus completed the conſideration of the organs in which the blood is contained, we now paſs on to take a view of the powers, by which thoſe organs are qualified and fully prepared to keep that vital fluid in motion.

Let us, in the firſt place, take an attentive and accurate ſurvey of thoſe powers which reſide in the heart itſelf, and which ought, without doubt, to be conſidered as by far the moſt active and eſſential in the great buſineſs of circulation: we will then proceed to conſider what may be called the ſecondary and aſſiſtant powers, which we will alſo find of high importance in the animal economy, from the concurrent and effective aid which they afford to the action of the heart.

§ 117.

It will at firſt view appear obvious to even the moſt ſuperficial obſerver, that it is a matter of Herculean difficulty indeed, either to aſcertain by accurate calculation the force of action exerted by the heart, or to determine with preciſion the quantity of blood thrown into the aorta by that organ at each pulſation; neither will the ſpeculative phyſiologiſt find himſelf beſet with difficulties of leſs moment, when he attempts to aſcertain and eſtabliſh with definitude, either the diſtance to which each projected wave of blood is carried by the impetus it receives from the heart alone, or yet the celerity with which ſuch wave rolls forward; but he will be ſurrounded with difficulties, ſtill encreaſing at each advancing ſtep, in his attempts to render a juſt ſtatement and accurate account of all ſuch obſtacles as oppoſe, and thus greatly diminiſh the effects of the force exerted by the heart, in its action on the circulating maſs of fluids.

§ 118.

A certain eſtimation may nevertheleſs be formed of the power of the heart, by collecting and comparing the moſt probable conjectures which have appeared on the above points of phyſiological ſpeculation. Thus for inſtance, if we ſuppoſe the whole maſs of blood to amount at a mean rate to

33 pounds, *i. e.* 396 ounces (§ 23), and eſtimate the number of pulſations at 75 in a minute, *i. e.* 4500 every hour (§ 109); and further, if we adopt the opinion that at each ſyſtole the left ventricle ejects two ounces of blood, it will then follow, that during the courſe of every hour the weight of the whole volume of blood makes 22¾ complete tranſitions through the heart. We may alſo form a tolerable conception and eſtimation of the impetus with which the circulating blood is propelled from the left ventricle of the heart, by obſerving with what aſtoniſhing violence, and to what a conſiderable height, the blood ſpouts from one of the larger arteries when wounded in the neighbourhood of the heart. Thus, from the wounded carotid of an adult ſubject, I have ſeen the blood, during a few of the firſt contractions of the heart after the accident, mount in jets to the height of at leaſt five feet.

§ 119.

But when we inſtitute an enquiry for the diſcovery of thoſe unfailing fountains or ſprings, which ſupply the heart with a force ſo powerful, and at the ſame time ſo uninterrupted and laſting, that which firſt attracts our attention, as being foremoſt both in point of time and importance is its *irritability*, (§ 44). This vital energy, as has been already evinced (§ 90), is much longer poſ-

feffed by the heart, than by any other mufcular part in the whole human body.

That the parietes, or walls themfeves of the cavities, are irritated and excited to contract by reiterated impreffions from the circulating waves of blood, is manifeft from a well known experiment of the illuftrious Haller. From this celebrated experiment, of that indefatigable phyfiologift and acute philofopher, it appears, that he could at pleafure grant, either to the right or left fide of the heart, the prerogative of a more protracted vital motion, (*i. e.* of longer life) accordingly as he firft deprived the one fide or the other of its peculiar ftimulus, the blood*.

§ 120.

When the proportional quantity of the blood is well adjufted to the fize of the containing veffels, and its quality uncontaminated by any morbid change, its action on the heart, and the re-action of that organ again on the blood, proceed with fuch an equable, regular and happy facility, that, when in a ftate of reft, we are fcarcely fenfible of the circulation of this vital fluid, which is the kind and conftant difpenfer of life and vigour to every part of our bodies.

* See Haller "De motu cordis a ftimulo nato," in Commentar. Soc. Scient. Goettingens, tom. i.

But

But if the circulating volume of blood be either too abundant, or preternaturally ſcanty, but eſpecially if this vital fluid be contaminated by the admixture of any foreign ſubſtance, as noxious miaſmata, air in an elaſtic ſtate, or poiſons injected into the veins, &c. the heart, either rouſed immediately into exceſſive action, or depreſſed to the oppoſite extreme of proſtration and debility, continues no longer fit for the ſalutary diſcharge of its important function, but falls into motions convulſive, irregular, and very widely different from the equable tenor of its healthy action. Foreign ſubſtances of the ſame kind, as air blown into the veins, &c. are alſo ſometimes able to rouſe again, and excite to motion, the heart of an animal recently dead.

§ 121.

It has been a point of controverſy, even in very modern times, whether this extreme irritability of the heart be eſſentially inherent in its own ſubſtance, or if it be not rather adventitious, and derived, as ſome celebrated characters would induce the world to believe, from the myſterious influence of the nerves? We will hereafter have a fit opportunity of declaring our ſentiments reſpecting the whole of this controverſy, when we come to conſider the doctrine of *muſcular irritability*, under which head, this ſubject of inquiry moſt naturally

 falls.

falls. On the prefent occafion it may fuffice to obferve, that I am daily more and more convinced, that irritability is a fpecies of vital energy altogether peculiar in its nature, belonging exclufively to mufcular fibres, and completely diftinct from the *vis nervea* (§ 34, 45.) But, on the other hand, it is no lefs evident and incontrovertible, that the nerves do alfo poffefs a very powerful influence and command over the action of the heart: this we learn, as well from the peculiar habit and appearance of the cardiac nerves, from their foftnefs, their defect of covering, and their fingular difpofition and arrangement, as from the aftonifhing confent of the heart with by far the greater number of the functions of the human body, even with thofe of the moft oppofite nature. In teftimony of the reality of this confent, it may be fufficient barely to mention, the fudden and tranfient fympathy which, even in a healthy fubject, exifts between all the paffions of the mind and the heart, together with that, which, in a great many fpecies of difeafe, manifefts itfelf between this organ and the *primæ viæ*.

§ 122.

But, befides thofe vital energies of the heart, it poffeffes alfo another power, arifing out of its mechanical ftructure, which appears to contribute not a little towards carrying on the circulation of the

the blood. The cavities of this organ being closely contracted, in the time of its systole, and the blood by this means completely expelled, a vacuum is thus produced, into which, on the principles of the well known law of *derivation*, the neighbouring blood must of necessity flow; for, as the valves prevent the regurgitation of the wave just ejected, it follows of course, that the cavities of the heart must then drink in, and swallow down, with rapidity, the blood advancing in the trunks of the veins.

§ 123.

We proceed now to enquire, whether or not, any of the other organs through which the blood passes, besides the heart itself, are furnished with powers contributary to the continuance of the circulation of that fluid. Judging from first principles, or *a priori*, as it is termed, we are led to suspect that such powers do exist; for it appears hardly probable, that the wisdom of nature has entrusted so important a function, on which the life of sanguiferous animals immediately depends, to one organ only, the faults and defects of which might, in such case, with too much facility, be attended with fatal consequences. But, reasoning *a posteriori*, as they term it, *i. e.* from actual observations, made on the animal economy, we are furnished with numerous facts sufficient to establish, beyond

beyond a doubt, the exiſtence of ſuch powers; which we may therefore term *ſecondary powers*, and which are able, not only to aid the action of the heart, but, in ſome caſes, to compenſate for almoſt the complete abſence of the influence of that important organ. A ſtriking inſtance of this nature, is the continued *motion* of the *blood*, in certain parts of the body, on which the power of the heart can have but very little effect, if indeed it can extend to them at all: this phenomenon is obſervable, as well in the venous ſyſtem of the liver, as in the placenta of the uterus; not to mention numerous inſtances of fœtuſes having been born, without the ſmalleſt veſtige of a heart.

§ 124.

Of theſe *ſecondary powers*, the firſt to be mentioned is, the *functions of the arteries*, the influence of which, in promoting and continuing the circulation of the blood, appears to be, indeed, very conſiderable; although the true principles and mode of their action, on this fluid, have not yet been fully developed and eſtabliſhed.

Speaking in general terms, there exiſts a very conſiderable reſemblance between the arteries and the heart itſelf: that the arteries, for example, have a *muſcular coat*, is a fact of the utmoſt publicity (§ 72.)

That

That they alſo poſſeſs irritability, has been very generally known, ſince the famous experiments of the illuſtrious Verſchuir.

And, further, as the aſpect or diſpoſition of the cardiac nerves on the heart itſelf is truly ſingular, thus alſo the larger branches of the arteries are, here and there, ſurrounded with aſtoniſhing reticular intertextures of ſoft nerves.

§ 125.

Finally, It is well known to every one that the arteries pulſate, and that indeed with ſuch vehemence and force, that if we ſuffer one of our legs to lie over the other knee, the pulſations of the popliteal artery are ſufficient to elevate in a ſubſultory manner, the ſuperincumbent leg not only alone, but even with a very conſiderable weight appended to it. Indeed for a long time paſt, both a ſyſtolic contraction and diaſtolic relaxation have been attributed to the arteries, which motions have been ſaid to correſpond and harmonize with the alternate contractions and dilatations of the ventircles of the heart.

Though the truth of this laſt propoſition is generally believed to be eſtabliſhed and confirmed by the ſimple teſtimony of the ſenſes themſelves, the ſubject is nevertheleſs ſtill embarraſſed with various

various doubts and difficulties: theſe difficulties immediately riſe to view, when it is aſked, whether this vibrating or pulſatory motion, which is felt on examination by the finger, is to be attributed to the inherent energy of the arteries, or to the impulſe of the heart; and whether the whole motion of the arteries does not depend ſolely on the impetus with which the blood is projected into the aorta, and thus impinges againſt the ſides of that tube, and its ramifications?

Diſſections of living animals have not been ſufficient to decide this controverſy. For it ſometimes happens that during the live-diſſections of warm blooded animals you may diſcover the larger arteries pulſating, while at other times again they appear in a ſtate of complete reſt. In man himſelf, while in the enjoyment of vitality, I had once an occaſional opportunity of obſerving the neighbouring trunks of the aorta and pulmonary artery, to be perfectly deſtitute of all motion; but it ſhould not be forgotten, that this phenomenon appeared in a caſe of monſtrous or preternatural formation of the parts. There are alſo arteries which we ſometimes feel in a ſtate of violent pulſation, and which we nevertheleſs know, from anatomy, are, in conſequence of their ſituation, almoſt immoveable; of this we have an example in

in the cerebral carotid, where it paſſes through the canal of the *os petroſum*.

§ 126.

When all circumſtances relative to this ſubject are impartially weighed and diſpaſſionately conſidered, this appears to be the reſult, viz. that the *diaſtole* of the larger arteries takes place in conſequence of their peculiar nature, and is to be attributed to the impetus of the blood ruſhing forcibly into them, and expanding their coats or tunics, which, by means of their elaſticity, immediately return again to their natural dimenſions. To the ſame impulſe alſo ſhould be attributed that lateral or curving motion of their axes, which may frequently be obſerved in the larger arteries when they run in a ſerpentine direction, and lie embedded in ſoft cellular membrane.

But in a ſound ſtate of the ſyſtem, we contend that the arteries ſcarcely exhibit any unequivocal proofs of a *true ſyſtole*, i. e. they do not by a genuine contraction recede from their *natural*, to *ſmaller* dimenſions, as long as the heart is adequate to the due performance of its momentous function; but although it be certain, that the arteries do not always, yet we acknowledge that they do ſometimes, exhibit and exerciſe a power of real contraction: thus for inſtance, when the heart is deficient

deficient in its action in consequence of labouring under either a morbid ossification, or some other species of disease, it is probable that then the duties of this important organ devolve on, and are discharged by, the arteries, and that the blood is thus kept in motion by the vital energy of those animated tubes.

§ 127.

As it has been the decided opinion of several celebrated physiologists, especially the famous Whytt, that the powers of the heart cannot possibly extend their influence to blood-vessels of the smallest order, as, for example, to the extreme terminations of the arteries, and to the incipient radicles of the veins; they have therefore attributed the motion of the blood, in that part of the system, to a certain oscillatory action of those minute vessels themselves, by the help of which their contents are propelled forward: and this same vibratory motion they have also applied, with a great deal of ingenuity, to explain and demonstrate the nature of inflammation, &c.

There are indeed a variety of phenomena, as well *physiological*, which shall be mentioned when on the subject of animal heat, as *pathological*, particularly observable in spasmodic affections, accompanied with fever, which seem to favour the existence

existence of such a power of oscillatory motion, although no such motion has ever been actually observed, even with the assistance of glasses, in the dissections of living animals.

§ 128.

It yet remains to enquire also after those assistant powers, by which the other parts of the veins, besides their radicles or incipient roots, are fitted to complete finally the return of the blood to the heart. It appears, indeed, at the first view of the subject, that the veins possess and exert a much smaller portion of the active vital energies than the other parts of the sanguiferous system, because the return of the vital fluid, contained in those vessels, towards the heart, seems to be owing to the impetus of the arterial blood urging it on by a *vis a tergo*, as well as to the valvular structure of the veins themselves, which effectually prevents the blood from regurgitating. That these minute valves are of the utmost importance in promoting and continuing the regular and free circulation of the blood, is satisfactorily demonstrated by the frequent congestions and infarctions, which happen in those veins that originate in the inferior parts of the abdominal cavity, and which are entirely destitute of such valves.

But

But there are neverthelefs a variety of arguments which render it probabl-, that the trunks of the veins do poffefs, and actually exert, certain degrees of the vital energies; as is well exemplified in the veins of the liver, and of the uterine placenta (§123.), &c.

It is alfo well known to every one, that the experiments firft inftituted by the illuftrious Verfchuir, are highly in favour of the exiftence of a vital energy in the veins.

And, that the two leading and extreme venous trunks have a ftratum of a true mufcular nature, we have briefly hinted on a former occafion (§ 84).

§ 129.

Thefe are indeed the leading powers which are active in promoting the circulation of the blood, and which derive their origin from the very ftructure of the veffels in which this fluid is contained. I fay nothing of the manner or degree in which the motion of this vital liquid is influenced by *weight*, *attraction*, or fuch other properties as are poffeffed by all bodies in common.

I alfo pafs over in filence the more remote and inconfiderable aids, which, in a human fubject after birth

birth, are afforded to the circulation of the blood, by the exercise of the other functionsof the system, such as respiration, muscular motion, &c.

SECT. XI.

OF RESPIRATION, AND ITS PRIMARY USE.

§ 130.

THE *lungs*, which are very intimately connected with the heart, as well from the vicinity of their situation, as from their uniform intercourse in the performance of their important function, are two viscera, large in the human subject after birth, but of such specific lightness, as to float on the surface of water. They consist of a parenchymatous substance, of a spungy texture, and even exhibiting somewhat the appearance of foam, yet still considerably tenacious and strong.

§ 131.

The lungs fill up the two cavities of the thorax, and thus lie in perfect contact with the sacs of the pleura, to which, as well as to the other parts contained in the thorax, they apply and accommodate themselves with the utmost definitude and exactness.

§ 132.

These viscera are appended to an air tube commonly called the *aspera arteria*, which, (besides an internal membrane, lined with mucus, under which is expanded a nervous intertexture of extreme sensibility), consists also of a muscular coat, which surrounds the nervous expansion, and on the posterior side is easily distinguished at the terminations of certain cartilaginous arches, which assist in the formation of the tube, but are not uniform in their number.

§ 133.

After the *aspera arteria* has entered the thorax it first forms, by bifurcation, the two trunks of the *bronchiæ*, which as they shoot still deeper and deeper into the *lobes* and *lobules* of the lungs, pass again, by reiterated divisions and subdivisions, into branches and ramifications, uniformly decreasing in size. During these progressive and multiplex divisions into inferior orders, both the small cartilaginous rings, and their muscular coat gradually disappear, till the evanescent extremities of the tubes finally terminate in those minute cells, which constitute by far the greater and more important part of the substance of the lungs, as their office is to receive, and again discharge the vivifying aerial element, in the process of respiration.

§ 134.

§ 134.

Thoſe ſmall air cells do not appear to poſſeſs uniformly, either the ſame *figure* or *dimenſions*. With reſpect to the former of theſe, (viz. their figure), it is in general that of a polyhedron. The latter, (*i. e.* their dimenſions), as far as their ſuperficial extent is embraced in the conſideration, cannot without the utmoſt difficulty, be aſcertained; but, if we conſider only their *aggregate capacity*, this, in the lungs of an adult ſubject, whoſe inſpirations are full and ſtrong, is ſufficient to admit and contain about 60 cubic inches of air. We do not here ſpeak of the immenſe ſize, to which the lungs may be expanded by inflation, after the thorax is opened, but only of the quantity and volume of air which they do actually admit in the living ſubject, when the proceſs of reſpiration is performed with eaſe and vigour.

§ 135.

Theſe veſicles or cells, deſtined for the reception of air, are every where ſurrounded and bound together by that common, but extremely tender, cellular membrane, which, as we have already learned, conſtitutes a general *vinculum* or bond of union to the whole body. But it is neceſſary to diſtinguiſh clearly and accurately between the two kinds of cells which exiſt in the pulmonic ſyſtem. I have ſeen the air cells ſo ſeparate and diſtinct,

 in

in the lungs of a healthy human fubject, that a perfon's breath, gently and cautioufly blown through a very minute and tender ramification of the bronchiæ, would elevate only a fingle circumfcribed clufter of veffels or cells, and would neither pafs into the neighbouring cells of the fame kind, nor yet into the common cellular membrane, which is every where interpofed between thofe cells intended for the reception of air. But, if the breath be urged with confiderable force, the air cells will be lacerated, and fuch a communication formed with the furrounding cellular membrane, as to give free paffage to the fubtle elaftic fluid, and thus the whole and every part, of the pulmonary lobe, will appear to be inflated.

§ 136.

This exceedingly tender cellular membrane, which enclofes and lies between the air veficles of the lungs, is every where interfperfed with innumerable fmall ramifications of both kinds of pulmonary veffels, viz. of the pulmonary artery, and of the four pulmonary veins, the branches of which accompany the branches of the bronchiæ, and afterwards, form in their courfe, by an immenfe number of divifions and fubfequent anaftomofes, reticular intertextures, and expanfions of extreme finenefs and fubtilty. This truly aftonifhing reticular tiffue, running in all directions through the

the cellular membrane, ſo completely ſurrounds, and cloſely embraces, the cells deſtined for the reception of air, that the whole volume of blood, which paſſes in an inceſſant round through the pulmonic ſyſtem, is ſeparated from the air taken in at each inſpiration, by nothing elſe than membranes ſo amazingly fine and ſubtle, as ſcarcely to be equal in thickneſs, (according to the obſervations and calculations of Hales), to the one thouſandth part of an inch.

§ 137.

As we have already obſerved, that each individual ramification of the bronchiæ has appended to it its own peculiar cluſter of air veſicles (§ 135), ſo likewiſe it appears, that to every individual veſicle of each cluſter is peculiarly appropriated its own ſyſtem of ſmall blood veſſels, the minute ramifications of which communicate very frequently with one another, forming thoſe ſurpriſing reticular tiſſues aleady ſpoken of, but ſcarcely appear to anaſtomoſe, in any degree, with the ſmall blood-veſſels of the adjacent cluſters. That this is a truth we are taught, if I am not deceived, as well from microſcopical obſervations made on the lungs of living frogs and ſerpents, as from more minute and ſucceſsful injections of the lungs of human ſubjects: the ſame thing is alſo further evidenced by certain pathological phenomena which may be

obſerved in *vomicæ*, and other ſimilar topical affec-tions of the pulmonic ſyſtem.

§ 138.

It is neceſſary to mention alſo, in the laſt place, that ſingular and ſtriking apparatus of lymphatic veſſels, which ſpreads and appears, in a more parti-cular manner, on the external membrane by which the lungs are inveſted. To this apparatus of veſ-ſels belongs that numerous aſſemblage of lympha-tic or conglobate glands, which, though of a quite different and diſtinct order, are nevertheleſs com-monly confounded, through miſtake, with thoſe glands in their neighbourhood, which are called *bronchiales*.

§ 139.

The *thorax*, in which the lungs are ſecurely encloſed, has for its foundation or ſkeleton, bones and cartilages, arranged and diſpoſed ſomewhat like the walls or ſides of a cave. Though this bony cavity, taken together as an entire whole, be to a conſiderable degree firm and ſteady, yet moſt of its parts are ſo pliant and moveable, as to be well adapted for the performance of thoſe mo-tions which the buſineſs of reſpiration requires.

This pliability, or facility of motion is particu-larly obſervable in ſix pairs of the true ribs, which being

being placed beneath the ſuperior and firſt pair, are more moveable in proportion as their ſituation is lower; or their aptitude for motion is commenſurate with the ſuperior length of their bodies, and cartilaginous appendices, which connect them to the margins on each ſide of the ſternum, by a ſpecies of articulation called *amphiarthroſis*.

§ 140.

Between the edges of thoſe ribs lie two ſtrata of intercoſtal muſcles, the fibres of which aſſume indeed and purſue different directions, but which, nevertheleſs, co-operate in their action in producing the ſame motion in the parts to which they are attached.

Acroſs the baſis or inferior part of the whole of this cavity the *diaphragm* is ſtretched, ſomewhat in the form and direction of an arch. This is a muſcle worthy of particular attention, and, to uſe the words of Haller, next in importance to the heart itſelf; its parts appear to depend chiefly on the phrenic nerve for their fitneſs to co-operate in the function of reſpiration, as was long ſince demonſtrated by the celebrated live-diſſections of the immortal Galen.

The

The diaphragm alternates for the moſt part, by an antagonizing motion, with the muſcles of the abdomen, eſpecially with the *external* and *internal oblique*, and the *tranſverſe* muſcles.

§ 141.

The thorax thus formed and finiſhed is, in the living human ſubject after birth, alternately dilated at the time of each inſpiration, and contracted again to its former dimenſions in every ſubſequent act of expiration.

In inſpiration, the enlargement of the thoracic cavity extends, in a more eſpecial manner, *laterally* and *downwards*, ſo that the bodies of thoſe ribs of which we have particularly ſpoken (§ 139) are elevated, and their inferior margins or edges turned in ſome degree outwards; while, at the ſame time, the arch of the diaphragm is ſomewhat depreſſed, and brought nearer to the poſition of a *plain*, or level ſurface.

But as to what is boldly aſſerted of the ſternum, viz. that its inferior end is at the ſame time protruded forward, this is a phenomenon which I muſt confeſs, I have never been able to obſerve in the tranquil and unmoleſted reſpiration of a healthy perſon.

§ 142.

This alternate motion of the thorax, which in a healthy ſubject is indeed performed ſpontaneouſly and without effort, is uniformly continued from the moment of birth to the extinction of life, for the following neceſſary and important purpoſes, namely, that the lungs themſelves may, by a ſimilar viciſſitude of motion, be expanded for the free admiſſion and convenient reception of the air we inſpire, and again contracted in order that the ſame may be forthwith expelled.

§ 143.

For man, together with all other warm blooded animals, is prevented, by abſolute neceſſity, from a lengthy retention of the air which he inſpires; he is obliged, after a very ſhort period to diſcharge it again, and exchange it for a freſh ſupply of this *vital pabulum* or *food*, as the air has been termed, even from the moſt remote ages. It appears indeed from the moſt common obſervation, that the air which is inſpired and retained any time in the lungs, however great may have been its original purity, ſuffers, in a very ſhort time, ſuch remarkable changes as affect it with the moſt obvious contamination, and, unleſs it be ſpeedily renewed, render it wholly unfit to be any farther employed in the important proceſs of reſpiration.

§ 144.

§ 144.

Enquiries have been inſtituted for the purpoſe of aſcertaining the nature of thoſe changes which the air we inſpire undergoes in our lungs. Such changes certainly do not ariſe, as was formerly believed, from the loſs of any myſterious principle of elaſticity, which reſides in the air, but are evidently produced by a decompoſition of its elementary parts. For the atmoſpheric air which we breathe is truly an aſtoniſhing mixture of elementary ſubſtances, very widely different from each other in their natures. Not to mention the various heterogenous matters which this neceſſary fluid contains; ſuch, for example, as the aerial ſeeds of the ſmalleſt and moſt ſimple plants, the odorous effluvia ariſing from numerous bodies, volumes of duſt, and a thouſand other ſimilar ſubſtances, which for the moſt part float in the atmoſphere. Not to mention, I ſay, theſe heterogenous bodies at all, the air which we breathe always contains aqueous exhalations in larger or ſmaller quantities, and is alſo more or leſs charged with the matters of electricity and magnetiſm. But finally, though the whole of the foregoing ſubſtances be left entirely out of view, yet even then the air of our atmoſphere does not conſiſt of one ſimple aeriform fluid, but is compoſed of dephlogiſticated, phlogiſticated, and fixed airs.

The

The proportion of thofe elementary matters, efpecially of fuch as are organic, is varied extremely from diverfity of places, and by the nature of the bodies which exift in thefe places. It is in the mean time, however, the common eftimation, that the air of our atmofphere confifts of about $\frac{1}{4}$th part of dephlogifticated, $\frac{11}{16}$ths of phlogifticated, and $\frac{1}{6}$th of fixed air.

§ 145.

It appears, that at each infpiration, (in which an adult fubject, breathing in a quiet and tranquil manner, draws in about 30 cubic inches of air,) a fourth part of the dephlogifticated air is decompofed, and, in a great meafure, exchanged for phlogifticated and fixed airs; fo that the expired fluid, being received into a proper veffel, extinguifhes flame or coals when immerfed into it, precipitates lime from the water which fufpends it, and far exceeds atmofpheric air in its fpecific gravity, &c.

§ 146.

It is probable that the igneous parts of the dephlogifticated air, *i. e.* thofe parts fuited to favour the procefs of combuftion, being fet at liberty by the decompofition which takes place in the lungs, enters the arterial blood, and is thus diftributed throughout the whole body; while, on the other hand,

hand, the basis of fixed air is carried back, along with the phlogisticated and venous blood, to the right side of the heart, and thence (as the ancients were pleased to express themselves) excreted through the lungs like soot.

The more florid dye of the arterial blood, the more obscure colour of the venous, and the similitude of colours imparted to both kinds of blood, when exposed to the action of those species of air now under our consideration (§ 16), are circumstances very much in favour of the preceding opinions.

§ 147.

In a fœtus which has never yet received vital air into its own pulmonic system, there is in general less difference between the arterial and venous blood, than in an adult subject, in whom the process of respiration has already taken place.

After the infant is born, the new sensation, excited by the contact of an unusual element, in an animal which had hitherto led an aquatic life, and the application of various other stimuli altogether new, appear to afford us a happy clue for explaining the new motions which at that period take place in the body, more especially the dilatation of the thorax and the first act of inspiration.

When

When the lungs are dilated by this firſt complete act of inſpiration, a new paſſage is thus opened through them for the blood, ſo that this fluid is ever after diverted from the umbilical veſſels to the thorax.

But when this inſpired air is, by that decompoſition of its elementary parts, of which we have already ſpoken, rendered both noxious and troubleſome to the lungs, I aſcribe to the moſt ſimple preſervative efforts of nature, the immediately ſubſequent motion, by which this poiſonous mephitis is exſpired, and profitably exchanged for a freſh ſupply of the foſtering pabulum of life.

From all the foregoing circumſtances, taken collectively, (eſpecially if we attend to the great influence of reſpiration on the circulation of the blood, as demonſtrated by the well known experiment of Hooke), we are furniſhed with a much better explanation of the celebrated problem of Harvey, than has yet been given by moſt of the other reiterated labours of phyſiologiſts, who have attempted to ſolve that difficulty.

SECT.

SECT. XII.

OF VOICE AND SPEECH.

§ 148.

THE leading function of respiration has been already the subject of our consideration. We will speak, in another place, of the part which this sublime process acts, in blending and intimately uniting the chyle with the blood, and also of the services which it renders, in a variety of ways, to almost the whole class of *natural functions*, (§ 63. 112.) We now proceed to consider its other uses in the animal economy.

The first object or phenomenon which attracts our attention, in this investigation, is the Voice, which belongs to the human subject after birth, and evidently proceeds from the lungs, as was long since very justly observed by Aristotle, who said, that no animals are vocal, *i. e.* possess the power of emitting sound, but such as breathe through lungs. For, by the denomination of *voice*, we properly designate that sound formed, by means of the exspired air, in the *larynx*, which is a small apparatus or machine of the most exquisite structure, placed on the top of the wind-pipe or *aspera arteria*,

arteria, ſomewhat like a capital on the ſummit of a column.

§ 149.

This ſmall machine is compoſed of various cartilages joined together ſomewhat after the form of a capſula or caſket. Theſe cartilages are furniſhed with a great and truly admirable apparatus of muſcles, in conſequence of which, not only the whole are rendered fit for motion collectively, but ſome of them are alſo enabled to move individually and alone, according to the different variations about to be produced in the voice.

§ 150.

That part which is more particularly engaged in the immediate generation of the voice is the *glottis*, a very narrow paſſage leading into the wind-pipe from above, to which is prefixed, or applied as a lid, a minute cartilage called the *epiglottis*. That ſound is produced by the air expelled from the lungs, ſtriking, in a proper direction and with due force, againſt the edges of this ſtrait paſſage, is a matter too plain to admit of a doubt.

§ 151.

Controverſies have exiſted on the ſubject of thoſe changes that take place in the glottis, by which the modulations of the voice are produced, namely,

namely, Whether this cartilaginous part be alternately expanded and contracted, as was the opinion of Galen, and afterwards of Dodart? or, Whether the variations of the voice do not rather depend on the tenſion and relaxation of its ligaments, as was held by Ferrein?

The latter of thoſe, therefore, compared the primary organ of the voice to a *violin*, the former to a *flute*—i. e. the one ſet of diſputants conceived it to emit ſound on the principles of a *corded*, the other on thoſe of a *wind*, *inſtrument* of muſic.

From a faithful collection, and impartial conſideration, of all the arguments which have been advanced on this conteſted point, we are of opinion, that both kinds of changes do actually take place in the glottis when employed in the emiſſion of ſound; but we, nevertheleſs, believe, that the principal and moſt important of thoſe changes depend on and ariſe from the tenſion of the ligaments, more eſpecially of the *thyreo-arytonöidei inferiores* (which appear to have been the vocal cords of Ferrein.

§ 152.

That all this mobility of the glottis, of whatever kind it may be, is influenced and wholly directed by the numerous muſcles which belong, and are

 attached,

attached, to the larynx, may be fully eſtabliſhed by the following beautiful experiment, viz. If the recurrent or wandering nerves (as they are termed) be either ſecured in light ligatures, or completely cut aſunder, the voice of the animals ſubjected to ſuch experiments, will be in the former caſe, rendered extremely weak and low, and in the latter, entirely deſtroyed.

§ 153.

The faculty of *whiſtling* belongs in common both to the human ſpecies, and to ſmall birds of note. To qualify them for this, ſinging birds are furniſhed with a bifurcated *larynx* at each extremity of the *aſpera arteria*. But though human ſubjects be ſupplied with only one plain and ſimple larynx, yet they learn to imitate thoſe ſmall animals, as appears to me, by a co-arction or puckering up of their lips.

§ 154.

But *ſong*, which is compoſed of ſpeech and a harmonious modulation of the voice, I would conſider as peculiar to man alone, and as conſtituting the leading prerogative of his vocal organs. The faculty of whiſtling is, as already obſerved, a part of the birth-right of birds: a numerous train of the feathered race, and ſometimes even dogs themſelves, have alſo been taught to pronounce a va-

riety of words. But I doubt extremely indeed, whether any brute animals have ever yet poſſeſſed a faculty of true and genuine ſong; whereas, on the other hand, I believe there ſcarcely exiſts a a nation ſo barbarous, where ſong does not very generally prevail.

§ 155.

Speech itſelf is a peculiar modification of the voice, chiefly by the aid of the tongue, but partially alſo by that of the lips, the teeth, the palate, and by the further aſſiſtance of the noſe, combined into the formation of words.

Hence the difference between *voice* and *ſpeech* appears very obvious and plain: the firſt is evidently formed in the larynx itſelf; whereas the latter is effected by the ſingular mechaniſm of the other organs already mentioned. It is but juſt and proper, however, to obſerve, that this laſt poſition is not capable of univerſal application, as there are a few nations (of which the Sinenſians may ſerve as an example), among whom their almoſt *homonymous** words are diſtinguiſhed only by a varied modulation of the *voice* itſelf.

* A word is ſaid to be homonymous, when it is highly equivocal, or uſed indiſcriminately to repreſent a diſcordant variety of objects or things.

But

But further, voice belongs in common to brutes as well as to man; it is poſſeſſed alſo by the new-born babe, nor is it wholly denied to ſuch unhappy infants as have paſſed their lives amidſt the haunts, and in the gloomy ſociety, of wild beaſts, nor even to thoſe that have been born without the ſenſe of hearing. But ſpeech is not acquired till after the cultivation and exerciſe of *reaſon;* it conſtitutes, therefore, no leſs than that operation of the mind itſelf, a characteriſtic privilege, and diſtinctive prerogative between man and the reſt of the animal kingdom. To ſerve all the purpoſes, and anſwer all the demands of brutes, that inſtinct with which nature has beneficently ſupplied them, is completely adequate; of this inſtinct, however, man is deſtitute, as alſo of ſuch other aids and individual powers as might enable him to preſerve and ſuſtain life by his own ſolitary exertions; he is therefore kindly furniſhed with the prerogatives of *reaſon* and *ſpeech*, by means of which, embracing the advantages, and diſcharging the duties, annexed to a ſocial ſtate, he is able both to diſcloſe his own wants, and relieve thoſe of his fellow creatures.

§ 156.

That truly admirable mechaniſm, by means of which ſpeech and the pronunciation of letters are

effected, has, since the celebrated researches of that paradoxical character, Franc. Mercur. Helmont, been very much illustrated and explained by further and later enquiries, especially those of Jo. Wallis and Conr. Ammanus.

That *division* of the letters by Ammanus into I. Vowels, II. Semivowels, and III. Consonants, is, of all others, by far the most simple and natural.

I. Vowels he again divides into *simple*, as *a*, *e*, *i*, *y*, *o*, *u*, and *mixed*, as, ä, ö, ü.

II. Semivowels are themselves either *nasals*, such as, *m*, *n*, *ng*, (i. e. *n* placed before *g* in the German language); or *Orals* (otherwise called *Linguals*) such as, *r*, *l*.

III. Finally, Consonants he divides, 1st, into the *Sibilantes* or *hissing* (i. e. into those consonants the pronunciation of which can be continued for an indefinite length of time). These are h, g, ch, s, sch, f, v, ph.

2dly, *Explosive*, as, *k*, *q*, *d*, *t*, *b*, *p*, and

3dly, Double (or Compound), such as, *x*, *z*.

§ 157.

Finally, It yet remains to mention certain other modifications of the human voice, which uſually occur as ſymptoms, or ſigns of either particular paſſions of the mind, or more violent affections of the organs of reſpiration. The greater part of theſe modifications of the voice, ſuch for example, as laughing and crying, appear to belong excluſively to the human race.

§ 158.

Moſt of the modifications which immediately follow, are connected together by ſuch a powerful kindred alliance, that one of them is not unfrequently obſerved to paſs into another. It muſt be alſo further obſerved, that the greater part of them do not always aſſume and exhibit the ſame uniform appearance, &c.

To ſpeak, however, in general terms, in the act of *laughing*, exſpirations ſhort, interrupted, and in ſome meaſure broken, follow each other in quick ſucceſſion.

Crying produces deep inſpirations, which ſuddenly alternate with lengthy exſpirations frequently interrupted and broken.

Sighing confifts in a lengthy, full, and ftrong infpiration, and a fubfequent flow exfpiration, which is not unfrequently accompanied with fomewhat of a *groan*.

Coughing is produced by quick and fonorous exfpirations fucceeding a deep infpiration.

Sneezing is a more violent and fomewhat convulfive exfpiration, which had been preceeded by a fhort and forcible infpiration.

The *Hickup* on the other hand confifts entirely of a fingle infpiration, *fonorous*, extremely *fudden*, and at the fame time of a *convulfive* nature.

The prefent feems a very fuitable occafion to fpeak of the phenomenon of yawning, which confifts in a full, flow, and lengthy infpiration, fucceeded again by a fimilar exfpiration, while, at the fame time, the jaws are drawn fo very widely afunder, that the air which is received into the expanded fauces can enter with eafe the *Euftachean tubes*. One thing peculiar to this phenomenon is, its being extremely contagious, i. e. it very readily excites to imitation: the caufe of this is, without doubt, to be fought for in the remembrance of the agreeable fenfatious produced at a former time, by the languid operation of yawning.

SECT.

SECT. XIII.

OF ANIMAL HEAT.

§ 159.

IT is worthy of obſervation, that man in a living ſtate, together with the other ſubjects belonging to the claſs Mammalia, as well as the whole feathered race, are diſtinguiſhed from the reſt of the animal kingdom by this peculiarity, that the native heat of their bodies far exceeds, in degrees of temperature, the uſual heat of the medium or element in which they live. With reſpect to man himſelf, it is however to be remembered, that he appears to be inferior, in the heat of his ſyſtem, to thoſe other kinds of animals we have juſt mentioned. Thus, in our climate, the heat of the human body generally ſtands at about the 96th degree of Fahrenheit's ſcale, whereas, in other animals belonging to the claſs Mammalia, the vital [temperature very conſiderably exceeds this point, while it aſcends ſtill higher in individuals of the feathered tribes.

§ 160.

Indeed, the degree of native heat poſſeſſed by a healthy perſon is ſo conſtant and uniform, that in

general, (provided we make allowance for the ſtate of health peculiar to each individual), its range will include but a very few degrees of the thermometer, whether the ſubject be expoſed to the inclemencies of the moſt rigorous climate, or placed beneath the fervors of a tropical ſky. For the opinion formerly delivered by Boerhaave, that man has not a power of exiſting in a medium of ſuch a nature as exceeds in temperature the native heat of his own body, has, ſince the famous obſervations of that illuſtrious traveller and former governor of Georgia, H. Ellis, been refuted by a great number of characters learned in the ſcience of phyſiology, and the reverſe completely demonſtrated and eſtabliſhed by experiments well adapted to the nature of the ſubject. In this particular, indeed, appears to conſiſt one of the great prerogatives of man, that impriſoned and confined to no one climate or zone of the earth, he is able to paſs his life in any ſection of the immenſe globe we inhabit, and is free to fix his habitation either beneath the rigors of Hudſon's ſtormy channel, where the quickſilver paſſes ſpontaneouſly to a ſtate of complete congelation, amidſt the tempeſts of Nova Zembla, or in the boſom of thoſe glaring ſolar fires, which ſcorch the glowing ſhores of the Senegal,

§ 161.

§ 161.

We proceed now to enquire into the origin and ſource of that aſtoniſhing fire, which minutely pervades our bodies, and uniformly ſupplies them with their neceſſary degrees of warmth. To paſs in ſilence over the viſionary conjectures of the ancients on this ſubject, ſome of the moderns have attempted to derive animal heat, with all its phenomena, from the matter of electricity and the nerves, others from the attrition generated by the circulation of the blood, others from the reciprocal friction between the ſolid elementary parts of living animals, while others, again, have embraced and defended different opinions.

§ 162.

But all thoſe hypotheſes are embarraſſed with inſurmountable difficulties, whereas, on the other hand, the utmoſt ſimplicity, and an entire correſpondence to the phenomena of nature, combine in recommending and confirming that doctrine, in which the lungs are conſidered as the *focus* or *fire-place* where animal heat is generated, and the dephlogiſticated part of the air which we breathe, as the *fuel* that ſupports the vital flame. That juſtly celebrated character, Jo. Mayow, ſketched out, formerly, the leading traces and firſt great outlines of this doctrine, which, in our times, has been greatly improved, extended, and farther elucidated,

elucidated, by the labours of the illuftrious Crawford.

§ 163.

The whole drift and tenor of Crawford's theory obvioufly refults in this, that *refpiration*, no lefs than *combuftion*, belongs to fuch proceffes as are called phlogiftic; in which the phlogifton refiding in, and conftituting a part of, our bodies, is expelled by the acceffion of *free* or *fenfible* heat, (which ought to be carefully diftinguifhed from heat exifting in a *fixed* or *latent* ftate.)

For phlogifton and the matter of heat are elements of fuch contrary and oppofite natures, that the greater quantity of the one our bodies at any time contain, the lefs, at the fame time, is their proportion of the other; thus, fixed air, for example, is not fuppofed to contain more than $\frac{1}{67}$th part of the quantity of the matter of heat, which belongs to an equal weight of atmofpheric air, &c.

But it appears, from experiments, that atmofpheric air has a ftronger affinity to phlogifton than to the matter of heat, fo that it unites itfelf with the greateft readinefs to the former, while, at the fame time, it fets at liberty the latter, which had been hitherto held in a fixed and latent ftate.

§ 164.

§ 164.

When we come to apply the foregoing poſitions and principles to the phenomena of reſpiration, it appears highly probable, that animal heat is generated by a proceſs of a ſimilar nature.

For, as we have already had occaſion to obſerve, the air which we exſpire differs, in a very remarkable degree, from what we had immediately before inſpired; being deprived of its igneous portion, or of that part fit for contributing to the ſupport of flame, it is returned highly impregnated, on the contrary, with phlogiſton and the baſe of fixed air. (§ 146.)

§ 165.

It appears, therefore, extremely probable, that the igneous portion of the air we breathe enters thoſe minute blood-veſſels, which are every where diſperſed throughout the ſubſtance of the lungs, and ſeparated from the air-veſicles themſelves by nothing more than ſubtle partitions of the moſt filmy texture (§ 136); that from the lungs it is conveyed through the pulmonary veins to the aorta, from whence it is again, by means of the arterial ſyſtem, diſtributed throughout every part of the body.

During the whole courfe of this minute diftribution, more efpecially while in the extreme ramifications of the veffels, it appears to be exchanged for phlogifton, which it every where meets with in confiderable quantities. This phlogiftic principle, being thus mixed with the blood, and occupying the place juft evacuated by the matter of heat, is conveyed back, by means of the venous fyftem to the right fide of the heart, and from thence by the pulmonary artery, into the lungs, where, agreeably to thofe laws of affinity which we juft now hinted at, it is immediately received and taken up by the volume of air recently infpired. In confequence of the acceffion of this quantity of phlogifton, and its union with the air contained in the lungs, a frefh portion of the element of fire or heat is fet at liberty, which inftantly enters the blood and is thus inceffantly diftributed throughout the fyftem in the manner already defcribed.

§ 166.

The truth of this theory is evidenced by thofe diverfities between arterial and venous blood, to which we have every where adverted. It is alfo farther evidenced by the difference between the fpecific heat of arterial, and that of venous blood; thus the fpecific heat of the blood contained in the arteries is to that of the blood contained

tained in the veins, as 11½ to 10. Finally, as an additional evidence of the fame thing, we might mention, in the laft place, that ofcillatory action exerted by the fmalleft order of blood veffels, which was the fubject of our attention on a former occafion.

§ 167.

For it feems altogether probable, that thofe extremely minute ramifications of the fanguiferous fyftem, are parts of fuch utility and importance, that in proportion as their action is ftronger or weaker, a correfpondent increafe or diminution takes place in that exchange of the element of fire for the matter of phlogifton, which goes conftantly forward in the body, and alfo in the heat of the animal uniformly generated by fuch exchange.

Thofe memorable and ftriking phenomena, from which it appears, that animal heat (if indeed the matter be determined by a thermometer, and not trufted to the fallacious teft of fenfation), remains in general at very nearly the fame precife point of temperature, little augmented by the fummer's blaze, little diminifhed by the winter's blaft; and further, that on certain occafions the heat of our bodies is even increafed in confequence of an immerfion in cold water—Thofe phenomena, I fay, feem to demonftrate, and reduce it to a certainty, that

that according to the variations that take place in the *temperature* of the medium in which we live, correſponding diverſities immediately follow in the *action* of the ſmalleſt vaſcular ramifications of our bodies. From this ſingularly accommodating power, reſident in the minute extremities of our vaſcular ſyſtem, it follows, that on being expoſed to cold (which appears to act by increaſing their tone), they are immediately enabled to exchange a *larger quantity* of the principle of phlogiſton for the igneous pabulum, and thus generate a higher degree of heat; whereas, on the other hand, they are obliged to exchange a much *ſmaller quantity*, as often as they are rendered inactive by being ſubjected to the influence of a relaxing and debilitating medium.

SECT. XIV.

OF CUTANEOUS PERSPIRATION.

§ 168.

SO various, and extremely diverſified, are the functions of the *cutis*, with which the human body is inveſted, that an enumeration and complete account of the whole of them can ſcarcely be comprehended with propriety under one

one and the ſame head; they would appear to be more fitly arranged for conſideration, each one under that *claſs* of *actions* to which, from its nature it belongs.

For, in the firſt place, the cutis is the organ of touch, of which we will ſpeak when treating of the *animal functions*.

It is again the medium or inſtrument of *inhalation*, by which office it makes a part of the abſorbing ſyſtem of lymphatics; this ſhall be a ſubject of further conſideration, when we come to take a view of the *natural functions*.

Finally, It is the laboratory or organ of *perſpiration* alſo. This function agrees in a great variety of reſpects with the proceſs of *reſpiration*, and appears therefore to be introduced with ſufficient propriety as the ſubject of the preſent ſection.

§ 169.

The cutis is ſaid to conſiſt of a threefold membrane, or of a membrane compoſed of three laminæ. Theſe laminæ or layers are the *corium* or true ſkin, lying on the interior ſide, the *cuticula* or cuticle making the exterior covering, and the *reticulum* (i. e. the *rete mucoſum*), which is ſpread

between

between the two laminæ juſt mentioned. Of each of theſe we will treat ſeverally and in order.

§ 170.

The *cuticle*, or epidermis, forms, as juſt obſerved, the external covering to the whole body: It is thus, from its ſituation, expoſed to a free acceſſion of the air, the immediate contact of which element, ſcarcely any other part of the body can bear with impunity, even in a ſound ſtate, except the enamel of the teeth, the tubes of reſpiration, and the alimentary canal.

§ 171.

The texture of the epidermis is ſimple to the utmoſt degree, being entirely deſtitute of veſſels, of nerves and of pores. This texture, though on the whole ſcarcely organic, is nevertheleſs highly ſingular and ſtriking; notwithſtanding its ſemipellucid and tender appearance, its tenacity is yet ſo very conſiderable as to reſiſt effectually, for a great length of time, not only maceration, but various other modes of generating putrefaction.

§ 172.

The origin of this filmy expanſion is as yet involved in doubts and difficulties. It is in the mean time, however, probable that it ſprings, along with the ſmall bulbs ſurrounding the roots

4 of

of the hairs, from the *corium* or true ſkin expanded beneath it: that this is the caſe, we are led to infer, from the myriads of minute and extremely tender fibrils, by which it and the ſkin are connected together.

When by any means deſtroyed, it is re-produced again with greater facility, than any of the other ſolid parts of the human body.

§ 173.

That this membranous lamina is of the utmoſt importance in the economy of organized bodies, is inconteſtibly evinced by its univerſal prevalence throughout both the animal and vegetable kingdoms. It may be obſerved already formed even in the tender embryo itſelf, at ſo early a period as the third month after the time of conception.

§ 174.

Underneath the cuticle is expanded a thin mucous membrane, which, from an opinion entertained reſpecting it, by its celebrated diſcoverer, is called *reticulum Malpighianum*.

This reticulum or ſubtle net-like expanſion, exhibits the habit and appearance of mucus, extremely eaſy of ſolution: it can ſcarcely in any part, except in the ſcrotum of Æthiopians, be ſepa-

rated entire from both the cuticle and true ſkin, and thus be procured in the form of a genuine and complete membrane.

§ 175.

The part now under conſideration, conſtitutes the primary and principal ſeat of colour in the human race. In all men the true ſkin is fair and ſhining; the cuticle alſo is ſemipellucid and whitiſh in all nations, except the inhabitants of Æthiopia, in whom it is more duſkiſh and obſcure. But in the human ſubject after birth, the colour of the *reticulum mucoſum* is varied, in correſpondence to the diverſities of age, mode of life, climate, and alſo in proportion as the conſtitution is more or leſs found.

Thus, for example, of the five *varieties*, into which the human race appears to me, to be with much propriety divided, the *firſt* has the reticulum more or leſs whitiſh. This deſcription includes, beſides Europeans, thoſe who inhabit the weſt of Aſia, and the north of Africa, together with the natives of Greenland and Eſquimaux.

2dly, In the ſecond variety, which includes the inhabitants of all the other parts of Aſia, the reticulum is ſomewhat tawny, inclining to an olive caſt.

3dly,

3*dly*, In the third, which embraces the inhabitants of Æthiopia, it is blackiſh.

4*thly*, In the fourth, which conſiſts of the aborigines of America, it is to a certain degree copper-coloured.

5*thly*, Finally, in the fifth, which comprehends the inhabitants of all the South Sea iſlands, it is more or leſs tawny or brown.

But all, and each one of thoſe varieties of colour, as well as all other varieties, by which man differs from man, and nation from nation, appear to be ſo intimately blended together, and are diſpoſed to run into each other with ſo much facility, that it ſeems ſcarcely poſſible to eſtabliſh any diviſions or claſſes of them, but ſuch as are plainly arbitrary.

§ 176.

The *Corium* or *true ſkin* itſelf, to which the *reticulum* and epidermis ſerve as a covering, is a membrane of a peculiar nature; it is porous, tenacious, capable of vaſt dilatation, varied in its degrees of thickneſs, conſiſting chiefly of condenſed cellular membrane, and extremely cloſe and compact on its external ſuperficies; it is more lax on the internal ſurface, which, (if you except a few

regions or parts of the body) (§ 36.) contains, for the moſt part, a certain quantity of common fat.

§ 177.

Beſides *nerves* and *abſorbents*, of which we will ſpeak particularly on a future occaſion, the *corium* or true ſkin is alſo plentifully ſupplied with innumerable *ſmall blood-veſſels*, which run on its exterior ſurface, and, as we learn from a ſucceſsful injection, inveſt the ſame with reticular expanſions of the moſt cloſe and ſubtile texture.

§ 178.

Over the ſame exterior ſurface is alſo interſperſed an immenſe aſſemblage of ſmall *ſebaceous follicles*, which thoroughly anoint the whole cutis with a very ſubtle and limpid oil, of ſuch a nature as not to be eaſily evaporated and dried up. This fine fluid ſhould neither be confounded with the *common ſweat*, nor yet with that fetid ſubſtance which infeſts only ſome particular parts of the body.

§ 179.

Finally, almoſt the whole of the true ſkin is planted with *hairs* of various kinds. The moſt numerous and abundant of theſe are very ſhort and tender, inclining more or leſs to the nature of down; of hairs which fall under this deſcription,

ſcarcely

ſcarcely any part of the body is deſtitute, except the eye-lids, the male penis, the palms of the hands, and the ſoles of the feet. But, on certain parts of the body, the hairs, being deſtined for particular uſes, grow to much greater lengths; examples of this we have in the hair of the head, in the eye-brows, in the eye-laſhes, the hairs in the noſtrils, the whiſkers, the beard, together with ſuch hairs as grow in the arm-pits, and about the anus and parts of generation.

§ 180.

In general, man is indeed leſs hairy than moſt other animals belonging to the claſs *mammalia*. A difference exiſts, however, in this reſpect, between the inhabitants of different countries. For, to paſs in ſilence over thoſe nations who are in the daily practice of plucking out, as well the beard, as the hairs which appear on other parts of the body, there are not wanting certain tribes, who are naturally deſtitute of hair; of this deſcription appear to be the Tunguſæ and the Buratæ. On the other hand, we are informed by travellers of the higheſt reputation in point of veracity, that the inhabitants of Nadigſda, one of the northern Kurilikian iſlands, are remarkable for the unuſual quantities of hair with which their bodies are protected.

§ 181.

Neither are the varieties fewer, which are exhibited by the hair, in regard to length, flexility, curlinefs, and, more efpecially, in point of colour: this laft property depends, in general, on the power of climate, on age, and other caufes, which exert their influence in perfect conformity to the eftablifhed laws of nature; but it fometimes alfo depends on a morbid and mifplaced temperament, as appears to be the cafe in the white natives of Æthiopia. The colour of the hair correfponds, for the moft part, to that of the eyes.

§ 182.

There is alfo a further peculiarity in the *direction* of the hairs, on certain parts of the body; thus, for example, on the *vertex* or crown of the head, they purfue a fpiral direction; on the pubes, they diverge and point upwards; on the pofterior fide of the arm, they look, (as on the ape, and contrary to their direction on the fatyr), towards the elbow, (that is, they point from the fhoulder downwards, and from the wrift upwards): of the directions purfued by the eye-brows and eye-lafhes, it feems unneceffary to fay any thing on the prefent occafion.

§ 183.

The hairs originate from the interior ſurface of the true ſkin, which contains a quantity of fat: they are fixed with conſiderable firmneſs in each of the ſmall bulbs, which are compoſed of *two involucra*; the external involucrum is vaſcular, and oval; the internal is cylindrical, appears continuous with the epidermis, and ſerves as an immediate covering to thoſe elaſtic filaments of which each individual hair is itſelf compoſed, and which are from five to ten in number.

§ 184.

The hairs are always completely beſmeared with an oily halitus, and are almoſt incorruptible. They appear to poſſeſs more of the nature of original electrics (or of *electra per ſe*, as they are called), than any of the other parts of the body. Their nutrition is extremely ſimple and eaſy, as is alſo their re-production after having fallen off, unleſs the cutis itſelf be labouring under ſome morbid affection.

§ 185.

Beſides other important purpoſes which theſe common integuments of the body ſerve, they are, in a particular manner, to be reckoned among the number of the *excretory organs* of the ſyſtem; by

their aſſiſtance, in this point of view, certain foreign matters, which would from retention prove highly noxious, are hourly eliminated and totally removed from the general volume of our fluids.

The truth of the above poſition is fully demonſtrated and eſtabliſhed, by the well-known circumſtance of miaſmata being completely removed from the ſyſtem, under the appearance of *exanthemata* or *eruptions;* it is alſo proved by the odours of garlic, muſk, and other ſubſtances taken into the body, paſſing by the ſkin; it is ſtill further demonſtrated and confirmed by the proceſs of ſweating, and by other phenomena of a ſimilar nature.

§ 186.

But above all, thoſe excretory paſſages convey off a certain fluid, which is called the *perſpirable matter* of *Sanctorius*, in honour of that moſt acute and ingenious philoſopher, who inſtituted the firſt ſeries of rational inquiries for the expreſs purpoſe of aſcertaining its utility and importance.

It is neceſſary, however, to obſerve, that under this appellation, phyſiologiſts commonly deſignate excrementitious matters, which, if not *oppoſite*, are at leaſt exceedingly *different*, in their natures, and which ought, therefore, to be diſtinguiſhed from each other with the utmoſt accuracy and care; as the

the excretion of *ſweat*, for inſtance, from the genuine matter of *perſpiration*.

The former (*i. e.* the ſweaty excretion) is a liquid of an aqueous nature, ſaltiſh to the taſte, and which ſcarcely ever iſſues ſpontaneouſly from the healthy body when in a ſtate of tranquility and reſt.

But the latter, (viz. the genuine matter of perſpiration), of which alone we intend to treat on the preſent occaſion, is an aeriform fluid, permanently elaſtic, and bearing a very ſtriking reſemblance to that which we exſpire by the lungs.

§ 187.

Like that elaſtic fluid, it is highly charged with the principle of phlogiſton, like that, it precipitates quick-lime from the water in which it was ſuſpended, and, like that, it is alſo unfit both for contributing to the nouriſhment of flame, and alſo for ſupporting the proceſs of reſpiration, &c.

§ 188.

The quantity of this fluid that exhales from the whole *ſuperficies* of the body (which, in an adult human ſubject of the middle ſize, amounts by meaſurement to about fifteen ſquare feet) can ſcarcely be reduced to accurate calculation.

For,

For, that the ſcales, which from the time of Sanctorius have been made uſe of for aſcertaining the exact weight of the body, are not well calculated for determining the preciſe quantity of this elaſtic fluid, may be eaſily underſtood from what we have juſt now ſaid reſpecting the different ſubſtances which are eliminated from the ſyſtem by the ſkin, beſides the true matter of perſpiration.

It was long ſince diſcovered, that the nature and quantity of perſpiration vary extremely, not only in different perſons, but even in the ſame perſons, at different times. It ſeems at preſent, however, to be a point too well aſcertained to admit of a doubt, that there does really exiſt, with reſpect to the matter perſpired, a national variety and peculiarity; the truth of this we confidently reſt on what has been ſaid, by authors of the higheſt veracity, with regard to the ſingular and ſpecific odours which are tranſpired through the ſkins of the Caribeans, of the Greenlanders, of the Æthiopians, and alſo of the individuals belonging to other barbarous tribes.

§ 189.

On conſidering what has been ſaid with reſpect to the vaſcularity obſervable in the texture of the ſkin (§ 177), and alſo with reſpect to the analogy that exiſts between the matter of perſpiration and the

the air we expire (§ 187); and further, on confidering what has been advanced refpecting the power and influence of the fmalleft vafcular ramifications, in the generation of animal heat—to him, I fay, who carefully weighs and attentively confiders all thefe circumftances, it will appear extremely probable, that there exifts a ftriking fimilitude indeed between the action of the lungs in refpiration, and that of the fkin in the procefs of perfpiration. It will appear that there exifts between the cutis and lungs a reciprocal confent; fo that the one may be fuppofed capable of affifting and fomewhat relieving the other, and even of fupplying its place, at leaft to a certain degree, in cafe of any accident or derangement.

§ 190.

In fupport of this opinion we can adduce the concurrent teftimonies of a variety of phenomena, obfervable not only in a *found*, but alfo in a *difeafed*, ftate of the fyftem.

Some of thefe phenomena are, for example, thofe leading points, in which the human fœtus, as well as that of the other animals belonging to the clafs mammalia, differ from the incubated chick, or the young of the feathered tribes, while yet enclofed in the *parietes* of the egg.

A further

A further evidence in favour of the ſame opinion, is that ſingular coldneſs of certain parts of the body, even in warm blooded animals, (as in the noſes of dogs, &c.) which appears to be referred with ſufficient propriety, to a leſs phlogiſtic action of the ſmall veſſels, with which thoſe parts abound.

On the contrary, from an encreaſed action of the minute veſſels in certain parts of the body, we explain, with the utmoſt fairneſs and facility, a variety of morbid ſymptoms, ſuch, for inſtance, as that ſingular heat and fluſhing in the palms of the hands, which occur ſo frequently, and are ſo ſtrikingly obſervable in patients labouring under a hectic fever.

With regard to that *vicarious action* of which we formerly ſpoke, and by which we ſaid it appeared probable, that the functions of the lungs and cutis lend mutual aid and aſſiſtance to each other; that ſuch an action does unequivocally exiſt, we derive ſome force of teſtimony from thoſe phenomena in pathology, where human ſubjects, after birth, and even after advancing to an adult age, having their lungs almoſt totally deſtroyed by a conſumption, or highly vitiated by ſome other contamination, have nevertheleſs ſurvived ſuch melancholy misfortunes, for a long time, and in

ſome

ſome caſes have even paſſed ſeveral years, during the whole of which period they appeared to be almoſt entirely deprived of the uſe and advantages of reſpiration.

§ 191.

Finally, It does not appear improbable, but that the interior ſurface of the *alimentary canal*, may alſo, beſides its other primary functions, be perpetually engaged in the performance of a phlogiſtic proceſs, not unlike that conducted by the *ſkin* and *pulmonary ſyſtem*.

This canal or tube appears, indeed, to be the only interior part of the body, except the lungs themſelves, to which the atmoſpheric air has free acceſs; but that the air has really free acceſs to the *primæ viæ*, or *firſt paſſages*, as they are called, and that we ſwallow that elaſtic fluid in conſiderable quantities, are matters, much too plain, to ſtand in need of any proof.

Further, That the air which we ſwallow undergoes a change very ſimilar to the change ſuffered by that taken by inſpiration into the lungs, is ſatisfactorily demonſtrated by the nature of the air contained in the whole alimentary canal.

Finally,

Finally, To all thofe concurring circumftances we may further add, that truly aftonifhing congeries of fmall blood veffels, fpread in profufion over the interior furface of the inteftines, which is commonly believed to be equal in extent to the external fuperficies of the whole body.

SECT. XV.

OF THE SENSORIUM AND NERVES.

§ 192.

WE come now to treat of another *clafs* of the functions of the human body, which embraces what we denominated the *animal functions* (§ 63): by means of thefe, an uninterrupted commerce and intercourfe are kept up between the body and the various faculties of the mind. They belong therefore exclufively, (as indeed the name itfelf plainly imports,) to organifed and animated bodies; but as they pervade the whole animal kingdom more univerfally than the vital functions, they appear to have an exceedingly juft and well founded claim to the epithet, *animal.*

§ 193.

§ 193.

The organs which are principally ſubſervient to the exerciſe of theſe functions are, the *cerebrum*, the *cerebellum*, and their appendage the *medulla ſpinalis*, together with the nerves that originate from theſe three ſources. The whole of theſe organs may, with ſufficient propriety, be arranged under two leading claſſes, namely, the *Senſorium* and *Nerves*. The former of theſe embraces (if we except the nerves themſelves, and thoſe parts which conſtitute their more immediate origins) all the remainder of that whole ſyſtem, which forms, more particularly, the *vinculum* or medium of connection, that exiſts between the offices or functions of the nerves and our nobler part, the faculties of the mind.

§ 194.

On this diviſion is founded that beautiful obſervation of the illuſtrious Sommering, in which he alledges, that the relative magnitude which the two preceding claſſes of organs bear to one another, correſponds ſo accurately with the faculties of the mind, that the ſmaller and leſs bulky the nerves of animals are, when compared to the ſize of the other organs or parts which we have comprehended under the denomination of *Senſorium*, the more vigorous and active are the faculties or their minds. In this reſpect he obſerves,

that

that man may be ſaid to poſſeſs the largeſt cerebrum or brain, if its bulk be compared to the ſmall ſize of the nerves that originate and proceed from it, but not if its weight be compared with the relative weight of the whole body.

§ 195.

Beſides the bony cranium or ſkull, in which the cerebrum itſelf is encloſed, it is ſtill farther inveſted with three involucra or coverings; theſe are the *dura* and *pia matres*, between which is expanded the third, viz. the *tunica arachnoidea*.

§ 196.

The *dura mater*, which lines, as a perioſteum, the cavity of the encephalon, is lengthened out into a variety of partitions or proceſſes. By its falciform proceſs, which is the moſt prominent and remarkable, it ſeparates from each other, the two hemiſpheres of the brain; while, by means of that proceſs called the *tentorium*, it forms a partition between the *cerebellum* and the parts ſituated above it, and thus, by giving ſupport to the poſterior lobes of the brain, prevents them from making an undue preſſure on the ſubjacent cerebellum.

Further, the dura mater, by various duplicatures or doublings of its own membrane, forms what are called the *venous ſinuſes*, while it gives them at

the ſame time firmneſs and ſupport, and prevents them from being unduly compreſſed. Through theſe ſinuſes the blood of the encephalon, or parts contained within the cranium, glides back towards the heart: this blood is ſaid, by phyſiologiſts, to poſſeſs properties peculiar to itſelf, and appears, from actual calculation, to be ſo conſiderable in quantity as to amount, at leaſt, to one tenth part of the whole maſs of blood contained in the human body.

§ 197.

Next to the dura mater lies the *tunica arachnoidea*, ſo called from its extreme tenderneſs and filmy texture. It is deſtitute of blood-veſſels, (§ 5.), and does not, any more than the dura mater, enter the various *ſulci* or furrows, and receive the different eminences or ridges, which mark the ſurface of the cerebrum, but only expands, with uniformity, over the whole volume of that important viſcus.

§ 198.

Very different from this is the ſtate and ſituation of the internal *involucrum* or covering of the brain, on which the ancients beſtowed the name of *pia mater*. This membrane every where accompanies the cortical part of the cerebrum ſo cloſely, that the innumerable ſmall blood-veſſels,

with which it is profufely fupplied, enter, and even perforate the cortex itfelf, with their infinitude of minute ramifications; hence, when the *pia mater* is feparated by force from the cerebrum, its external furface prefents a fmooth and exquifitely beautiful polifh, while its internal furface, on the contrary, is confiderably villous, and refembles, not a little, thofe delicate radicles by which the moffes adhere to their native foil, or places of growth.

§ 199.

Both the cerebrum and cerebellum are compofed of a variety of parts, different from each other both in texture and figure, the ufes of which have been hitherto generally unknown: thefe parts are particularly diftinguifhed by the four *ventricles*, as they are called, the communication between which has been of late traced and developed, with the utmoft accuracy, by the illuftrious Monro: of thefe ventricles, the two anterior and the fourth contain what are denominated the *plexus choroidei*, the ufes and functions of which are alfo involved, as yet, in intricacy and doubt.

§ 200.

In all parts, of both the cerebrum and cerebellum, there exift two kinds of fubftance, one of a cineritious or afh-colour, which is called the *cortical* part, although it does not always form the exterior

exterior ſtratum, the other white and ſhining, and therefore called the *medullary* portion. Agreeably to the obſervations of the illuſtrious Sommering, there is interpoſed between the two foregoing ſubſtances, ſtill a third, of a colour bordering on white; this body is moſt conſpicuouſly obſervable in the *arbor vitæ* of the cerebellum, and in the poſterior lobes of the cerebrum.

§ 201.

The proportion, which the cineritious ſubſtance bears to the medullary, decreaſes as life advances; thus, in infants it is greater, in adults leſs. Almoſt the whole of this cineritious ſubſtance, is compoſed of an immenſe aſſemblage and contexture of the ſmalleſt ſized blood-veſſels, together with veſſels of an order ſtill inferior, even ſo minute as to be incapable of admitting any thing except a white or colourleſs fluid of the moſt exquiſite tenuity, (§ 79.): a ſmall number of theſe veſſels paſſes into the medullary portion, which appears to contain in its own compoſition, (beſides theſe minute veſſels and a quantity of very tender cellular membrane), a ſoft pultaceous parenchyma, in which phyſiologiſts, even when armed and aided by the moſt powerful glaſſes, have not yet been able to diſcover any uniform and definite texture.

§ 202.

In the cerebrum is obfervable a perpetual but very gentle motion, bearing fuch a relation and exact correfpondence to the procefs of refpiration, that while the lungs are collapfed, and their volume diminifhed in the act of exfpiration, the cerebrum is flightly elevated, but immediately fubfides again, when the thorax is dilated by means of a fubfequent act of infpiration.

§ 203.

What has been called by phyfiologifts the *medulla oblongata*, terminates in the *medulla fpinalis*, which is contained in that flexible tube, formed by the vertebræ of the fpine or back, and is ftill clothed in the fame membranes which we have already feen inverting the cerebrum or brain itfelf: further, as the brain, fo likewife the fpinal marrow, is found to confift of two kinds of fubftance, with this ftriking circumftantial difference, however, that, in the latter, the cineritious or afh-coloured fubftance forms the internal, whilft the fhining or medullary compofes the external, part.

§ 204.

From each of the foregoing fources, namely, the cerebrum and cerebellum, together with the medulla fpinalis, the *nerves* primarily derive their origins. Thefe are fmall ropes or cords, of a colour

colour more or leſs whitiſh, differing likewiſe in their degree of firmneſs), which are minutely diſtributed throughout almoſt all the other ſoft parts of the human body. This opinion of the minute, and *univerſal*, diſtribution of the nerves through every part of the human ſyſtem, though admiſſible as a general rule, is, however, ſubject to certain well founded exceptions.

§ 204.

For it appears from an infinitude of experiments made by the illuſtrious Haller, and other able obſervers, that there are ſeveral of the *partes ſimilares* (or ſimilar parts § 46) of our bodies, in which, the knife, and powerfully armed eye of the anatomiſt, have not been able to detect the ſmalleſt veſtige of nerves, and where neither ſurgical obſervations nor live diſſections, often repeated by the moſt dextrous hand, have ſucceeded in diſcovering even the fainteſt phenomena of ſenſibility.

In an enumeration of ſuch parts, as appear to be deſtitute of ſenſation and nerves, we muſt embrace, beſides the naked cellular membrane, the epidermis, the *reticulum mucoſum*, the hairs, and the nails.

We include further, the cartilages, and bones, with their perioſtia and marrow.

To theſe muſt be added, the tendons, the aponeuroſes, and ligaments; as alſo moſt of the broader and more extenſive membranes, ſuch, for example, as the dura mater and tunica arachnoidea; the pleura, with the mediaſtinæ and pericardium; the peritoneum; the cornea, &c.

Under the ſame head we arrange moſt parts of the abſorbent ſyſtem, but more eſpecially the thoracic duct.

Finally, This catalogue of ſuch parts as neither poſſeſs nerves, nor are endued with ſenſibility, ſhall be cloſed, by the addition of the *ſecundines*, and *umbilical cord*.

§ 206.

The primary or naſcent origins of the nerves, emerging from the ſenſorium itſelf, have, as yet, eluded the moſt zealous reſearches of the ſubtle knife and prying eye of the anatomiſt: it therefore ſtill remains a matter of controverſy and doubt, whether the nerves on each ſide of the body derive their origins from the *correſponding*, or from the *oppoſite* ſide of the ſenſorium? Certain pathological phenomena appear indeed to fa-

vour

vour the latter of thefe opinions. It has been alfo lately eftablifhed by the illuftrious Sommering that a true decuffation or croffing of the optic nerves does actually exift.

§ 207.

A certain continuation of the pia mater accompanies the medullary part of the nerves in their courfe, in fuch a manner, as to form for them a vafcular cortex, or covering, of extreme tendernefs. No fooner, however, do thefe cords emerge from the cerebrum, or the fpinal marrow, than they affume a very fingular habit and appearance, by which they may be readily diftinguifhed from almoft all the other fimilar parts of the body. This peculiarity of appearance is produced by fmall plicæ or folds, which they exhibit, running in angular directions, more or lefs oblique. Thefe folds were formerly defcribed by P. P. Molinel, who compared them, not inconfiftently with propriety and fitnefs, to the rugæ of the *lumbricus*, or round worm, or to the fmall rings of the afpera arteria.

§ 208.

The nerves, efpecially thofe of the fingle or unpaired orders, fuch, for inftance, as the intercoftal and vagantes or wandering nerves, are every where furnifhed with *ganglia*, *i. e.* fmall

 bulbs,

bulbs, of a texture confiderably compact, and of a cineritious colour, fomewhat inclining to a pale red: the functions and ufes of thefe bodies in the animal economy have not yet been fatisfactorily afcertained and demonftrated. We are, however, in the mean time, moft inclined to adopt the opinion formerly entertained refpecting thefe fubftances by the ingenious Zinn. That acute phyfiologift believed the ganglia to confift entirely of mazy complications and intertextures of minute nervous filaments originating from different fources. In confequence of this intricate and uninveftigated texture of thefe bodies, he conjectured, that each nervous filament, or thread proceeding from them, participates, or contains in its compofition, a part of every filament that enters into their ftructure, however numerous thofe filaments may be, or however different the fources from which they originate.

§ 209.

Neither does there appear to exift any very material difference between the nature of ganglia, as juft defcribed, and of what are called *plexus nervofi*. Thefe latter are alfo indebted, for their exiftence and form, to a fimilar concurrence and anaftomofing intertexture of nerves that originate from different fources. The compofition of fuch nervous filaments as ramify and proceed from thefe

plexus

plexus nervoſi, appears to be alſo perfectly analogous to the compoſition of thoſe, that originate from the ganglia, of which we have already ſpoken.

§ 210.

But as the *naſcent origins* of the nerves, ſo likewiſe (with a few exceptions), the *final terminations* of their *extreme ramuli*, or remote filamentary branches, are as yet involved in the depth of obſcurity. For if we except thoſe few nerves that terminate in a kind of medullary expanſion, as the optic nerve in the *retina*, and the ſoft portion of the ſeventh pair, in that pulpy zone, contained between the ſpiral laminæ of the cochlea of the ear —If, I ſay, we except theſe two nerves, the evaneſcent filaments of ſuch of the others as enter the viſcera, the muſcles, the ſkin, &c. become ſo minutely blended with the real parenchyma of the parts on which they are diſtributed, and gradually aſſume ſuch a pulpy conſiſtence, that the eye of the anatomiſt can no longer trace them through their mazy courſes.

SECT.

SECT. XVI.

OF THE FUNCTIONS OF THE NERVOUS SYSTEM IN GENERAL.

§ 211.

WE have thus ſeen, that of the ſenſorium, and nerves ſo generally and minutely diſtributed throughout moſt parts of the body, a complete ſyſtem is beautifully conſtituted, which, during the continuance of life, ſerves as a medium of communication and mutual intercourſe between the body and the mind.

§ 212.

Various circumſtances and phenomena combine in rendering it probable, that the mind is indeed attached and cloſely connected to the brain itſelf. That the brain is thus honoured and dignified in its alliance is very powerfully and ſtrikingly evidenced, by moſt of the inſtruments of ſenſation being ſituated in the very vicinity of that organ; by the aſtoniſhing conformation of its various parts, conſidered with regard to their figure and ſtructure; but more eſpecially by the phenomena attendant on its morbid affections.

§ 213.

§ 213.

With refpect to that connection of which we have juft hinted, I would further obferve, that certain phyfiologifts, wantonly fporting in the delufive fields of imagination, have fuffered themfelves to be fo far influenced by the form and fituation of particular parts of the encephalon, that they have confidered, and even endeavoured to prove, fometimes one, fometimes another of thefe parts, to be indeed the very feat, and royal court, (as it were) of the mind. This honorary and fublime privilege, of affording a facred feat to our nobler and *immortal part*, fome metaphyfical phyfiologifts have been folicitous to beftow on the pineal gland *, others on the cerebellum, others on the corpus callofum †, and

* In favour of the Cartefian hypothefis, fome degree of teftimony appeared to be derived from the diffections of certain *maniacs*, in whom the pineal gland was found invefted with calculous concretions. On more accurate obfervation, however, it was difcovered, that not only in maniacs, but alfo in numerous other fubjects poffeffing the moft complete degree of mental fanity, this fame glandular body was furrounded, from about the 12th year of life, by minute fandy concretions of a pearl-like appearance.—Cl. Sommering de lapillis vel prope vel intra glandulam pinealem fitis, f. de acernulo cerebri Mogunt. 1785. 8.

† Thofe fictitious prerogatives both of the cerebellum and corpus callofum are refuted in a very mafterly manner by

Zinn

others, again, on that part which has been denominated pons Varolii.

§ 214.

We are not by any means to ſuppoſe, that the whole energy of the nervous ſyſtem depends on the encephalon alone; it is alſo derived in part from the ſpinal marrow, and even the nerves themſelves poſſeſs ſuch a degree of inherent or native energy, as is ſufficient of itſelf to throw the muſcles into a ſtate of convulſion. This native or excluſive energy of the nerves, appears to be principally ſupported and preſerved by that vaſcular cortex or covering of thoſe organs, of which we briefly ſpoke on a former occaſion (§ 205). It is, however, a truth which ought not to be forgotten, that this inherent power of the nerves themſelves is *leſs*, and that energy, on the contrary, which is derived immediately from the encephalon, *greater*, in man, than in other animals, eſpecially ſuch as are ſupplied with cold blood.

§ 215.

The office of the nervous ſyſtem appears, in a particular manner, to be two-fold. *Firſt*, by means

Zinn in his "Experim. circa corpus calloſum, cerebellum, duram meningem, in vivis animalibus inſtitut. Goetting. 1749. 4.

of

of this ſyſtem, other parts of the body, eſpecially ſuch muſcles as are ſubjected to the influence of the will, are excited to motion; of this function, however, we will treat more fully in another place. But, ſecondly, the nerves are peculiarly ſubſervient to ſenſation; whatever ſenſible impreſſions are made on the body, they, like active heralds, convey and announce immediately to the ſenſorium, and there give riſe to perception.

§ 216.

Finally, the ſenſorium is evidently poſſeſſed of the following very ſingular faculty or power, viz. that, having received ſenſible impreſſions through the medium and agency of certain nerves, it is able to re-act again in its turn, not only on the ſame nerves, but alſo on ſuch as are completely different. In teſtimony of the truth and authenticity of this poſition, it will be ſufficient to mention the action of the retina, when affected by light, on the ſenſorium, and the re-action of this latter, again, in either conſtricting or dilating the iris.

§ 217.

It is principally from this laſt ſource, that we are to derive and explain moſt of the effects of the imagination, and paſſions of the mind, on the human body: of theſe effects we will ſpeak more

more fully on a future occaſion. To the ſame ſource, alſo, muſt we refer that extenſive and diverſified conſent of the *nervous ſyſtem*, which prevails throughout almoſt the whole body (§ 14.), and the aſtoniſhing power and influence of the ſame, over moſt of the other functions of the animal economy.

§ 218.

That the phenomena which we have juſt mentioned, proceed from certain properties eſſential to the nervous ſyſtem, is a poſition, that appears, from obſervation and experiment, to be founded on the moſt indubitable evidence. But, to elucidate and explain the manner in which this ſyſtem acts, in the production of ſuch phenomena, is, indeed, a difficulty of the utmoſt magnitude.

§ 219.

When we view the ſubject in a general light, the various opinions, which have at different times been advanced on this conteſted point, may be all referred to two leading claſſes: one of theſe alleges the action of the nervous ſyſtem, to depend on a certain oſcillatory motion; while the other ſuppoſes it to be produced by the motion of a peculiar fluid, reſpecting the nature of which phyſiologiſts, again, hold different opinions. Thus, while ſome believe this fluid to be animal ſpirits, contained

contained in, and paſſing through, veſſels, others contend, that it is a certain modification of matter, ſimilar to fire, electricity, or the magnetic effluvia.

§ 220.

Although I am diſpoſed to adopt neither of the above opinions as my own, yet it is proper to obſerve, that moſt of the arguments, by which the advocates of either *hypotheſis* have endeavoured to invalidate the other, appear to me to be as crude and inconcluſive, as they ought to be ſubtle, ingenious and forcible. This obſervation applies, as well to the arguments made uſe of to prove the oſcillations of the nerves, as to thoſe advanced for the purpoſe of eſtabliſhing the exiſtence of a nervous fluid.

§ 221.

If, indeed, our views of the ſubject be not erroneous, the two foregoing opinions may, without impropriety, be united, and thus a third one formed, more plauſible, at leaſt, than either of the originals, namely, that a certain nervous fluid does actually exiſt, and that this fluid is alſo capable of motion, and of being thrown into oſcillatory vibrations, when ſubjected to the action and influence of ſtimuli.

§ 222.

§ 222.

Not to mention various other evidences, which might be obviouſly deduced, from the different phenomena of the nervous ſyſtem, the *ſtructure* of the brain itſelf, which bears a ſtriking reſemblance to *that* of certain ſecreting viſcera, appears indeed to be highly in favour of the exiſtence of a nervous fluid. It is ſurely a matter too obvious to admit of controverſy, that there is no more need of any direct tubes and canals, for the diſtribution of ſuch a fluid through the nerves, than there is, for the conveyance of a liquid through brown paper, or any other filtre.

The nugatory calculations, reſpecting the aſtoniſhing rapidity, with which the animal ſpirits have been ſuppoſed to hurry through their nervous canals, in all parts of the ſyſtem, are ſubjects too hypothetical and viſionary to merit our time, or command our attention.

§ 223.

That an oſcillation of the nerves does indeed exiſt, is a poſition, powerfully ſupported by a great variety of very ſtriking and pointed phyſiological phenomena. This oſcillation muſt not, however, be ſuppoſed to bear any reſemblance to the rude vibrations of tenſe chords, but is ſuch a ſubtle, tremulous motion, as may be readily conceived to

take place in the tender, pulpy ſubſtance of the brain. That hearing is excited by an oſcillation of a liquid, has been reduced to ſatisfactory demonſtration. That an oſcillatory motion ſomewhat ſimilar takes place alſo, in the act of viſion, is (though we ſhould not be willing to repoſe implicit confidence in the opinions of Leon. Euler) a poſition founded, at leaſt, on ſtrong probabilities. That the action of the other ſenſes depends alſo on an oſcillatory motion of a ſimilar nature, is an opinion, which was not only embraced by the illuſtrious Newton *, but has been ſince ably and ſucceſsfully defended in the writings of the ſagacious Hartley. It is on the principle of the exiſtence of ſuch a motion, that this laſt mentioned author, has firſt happily accounted for the aſſociation of ideas, and then, by the aid of this, proceeded to explain, with the utmoſt ingenuity, moſt of the functions performed by the different faculties of the mind †.

* Vide ejus Quæſtiones ad calcem optices. Qu. 23. p. 355. edit. Lond. 1719-8.

† David Hartley's Obſervations on man, his frame, his duty, and his expectations. Lond. 1749, vol. ii. 8.

SECT. XVII.

OF THE EXTERNAL SENSES IN GENERAL, BUT PARTICULARLY OF THE TOUCH.

§ 224.

ONE office of the nerves, as we have already had occafion to obferve, confifts in communicating to the fenforium, impreffions made by external objects. This they do through the medium of the *external fenfes*, which officiate as watchful centinels to the body, and diligent inftructors to the mind.

Thefe, therefore, fhall conftitute, at prefent, the *fole object* of our confideration. For to arrange among the fenfes, the ftimulus or propenfity which animals feel to evacuate their fæces, the fenfation of hunger to which they are fubjected, or other internal calls of nature of a fimilar kind, would be, as Haller formerly obferved, an unneceffary fpecies of fubtility and refinement.

225.

It ought to be remembered, that no other clafs of functions belonging to the animal economy, is fubjected to fuch an aftonifhing variety in different individuals, as that of the external fenfes, which

conftitutes

constitutes the subject of our present consideration. This infinite diversity, which exists between these senses in different individuals, is either natural or acquired, and relates to their greater or less acumen or sharpness, their subtlety, or to the manner in which they are affected by similar applications of the same stimuli.

§ 226.

In giving an entire and complete account of the external senses, it appears most proper to begin with *the touch*, this being the one which manifests itself at the earliest period in the human subject after birth. The organ of the sense of touch is expanded over the whole superficies of the body, and is so constituted and formed as to be affected by much the greatest number of the properties of external objects.

§ 227.

For we are not only made sensible of certain qualities of substances by means of the touch alone, as of heat, hardness, weight, &c. but there also exist other qualities, such, for instance, as figure, distance, &c. of which we acquire, a much more certain and accurate knowledge by the aid of the touch, though it must be acknowledged that these qualities are at the same time subject to the cognizance of some of the rest of our senses.

§ 228.

The touch is lefs liable to deception than the other fenfes; and is capable of becoming, by cultivation and attention, fo exquifitely perfect and refined, as to be able to compenfate, in a certain degree, for any deficiency in its fifter fenfes, more efpecially in that of vifion.

§ 229.

The organ of this fenfe is indeed the fkin in general, concerning the fabric and texture of which we fpoke formerly; but thofe parts that are more immediately fubfervient to the touch, are the papillæ of the *corium* or *cutis vera;* thefe papillæ exhibit various figures in different parts of the body; they are indeed, for the moft part, *verrucofe*, in other places they are *fungous*, in others *filamentous* or thread-like, &c. under all which appearances, the extremities of the cutaneous nerves terminate after the manner of fmall pulpy pencils.

§ 230.

But by far the moft important and diftinguifhed inftruments of the touch are, in particular, *the hands*, the fkin of which is impreffed with a great number of ftriking peculiarities. Thus, for example, the fkin on the palms of the hands, and on each fide of the joints of the fingers, is fulcated and completely deftitute of hair, for the purpofe of facilitating

facilitating the folding or doubling up of thofe parts. The extremities of the fingers, on their *internal*, and of the toes, on their *inferior*, furfaces, are furrowed with flight and very elegant grooves running in directions more or lefs fpiral: but the former, on the exterior, and the latter on the fuperior, fides, of their terminations, are protected from injury by nails.

§ 231.

Thefe fcutiform *nails* are poffeffed only by man, and a few other animals, (belonging to the clafs *mammalia*), which are alfo furnifhed with hands, and excel in the acutenefs of their fenfe of touch. Thefe nails appear to be defigned for the purpofe of making a gentle refiftance to the preffure of the fingers when examining fubftances, and thus aiding their action.

The nails, though of a horny nature, muft neverthelefs be confidered, on the whole, as productions or continuations of the epidermis: for immediately under them lies the reticulum mucofum, which in Æthiopians is black; and finally, beneath this again is expanded the corium or true fkin, which is firmly attached to the perioftium of the extreme phalanx of the fingers. Alfo thefe conftituent parts of the nails are ftriated in a longitudinal direction. At their pofterior margins

(which are diſtinguiſhed by ſmall ſemilunar ſegments, of a ſhining or ſomewhat brilliant appearance) they are ſecurely fixed in a groove formed by a reflection of the cutis, from whence by a daily, but very moderate, increaſe, they are gradually protruded forward, in ſuch a manner, as to be completely renovated in every term of about ſix months.

SECT. XVIII.

OF THE TASTE.

§ 232.

TASTES are certain impreſſions made on, and perceived by, the tongue, and alſo, in ſome meaſure, by the adjoining cutaneous parts of the *os internum* (*i. e.* the inſide of the mouth); theſe parts are, in particular, the *medium palati*, the fauces, the cheeks, and even the lips themſelves; with reſpect, however, to the whole of theſe auxiliary parts, it is proper to obſerve, that they have no perception of any taſtes except ſuch as are acrid or intenſely bitter.

§ 233.

The principal inftrument of tafte is *the tongue*, an organ capable of the utmoft agility in motion, very pliable, and exceedingly changeable in point of form: it confifts of a flefhy texture, which exhibits a ftriking appearance, fomewhat refembling the texture of the heart.

§ 234.

It is invefted with involucra or coverings, which bear a fimilitude to the different ftrata of the cutis: thefe are, the epithelion, which correfponds to the cuticle, the reticulum Malpighianum, and laftly, a papillary membrane, that differs but little in its ftructure from the corium or true fkin.

§ 235.

The principal difference confifts in this, that the epithelion, inftead of a fine cutaneous oil, is lubricated and moiftened by mucus, which exfudes from that imperceptible orifice, named after Meibomius, and alfo from the reft of that glandular expanfion, difcovered by Morgagni: another point of difference is, the conformation of the papillæ, which are divided into the *petiolated*, the *obtufe*, and the *conical*; of thefe, the former, being very few in number, are placed in a lunated arrangement, at the root of the tongue, while the others, being of various fizes, are crouded promifcuoufly

and without order, on the back of the tongue, but more eſpecially on its edges and tip, where the ſenſe of taſte is moſt acute and exquiſite.

§ 236.

To theſe papillæ paſs the extreme filaments of the lingual branch of the fifth pair of nerves, by the offices and aid of which it appears probable, that the ſenſe of taſte is proximately generated and preſerved.

For the ninth pair of nerves, and alſo that branch of the eighth, which is diſtributed throughout the tongue, appear to be ſubſervient to the various motions performed by that organ in chewing, ſwallowing, ſpeaking, &c. rather than to its function as the immediate inſtrument of taſte.

§ 237.

That the tongue may exerciſe the ſenſe of taſte in perfection, it is neceſſary for it to be kept in a ſtate of complete humidity; the ſubſtance to be taſted ſhould alſo be a liquid, and ought to abound with ſalts in a ſtate of ſolution: for if either the tongue itſelf, or the ſubſtances applied to it be dry, it may then indeed examine them by the touch, which it generally poſſeſſes in an exquiſite degree, but cannot with ſtrictneſs and propriety be ſaid to taſte them.

When

When the tongue difcharges the office of tafting with moft perfection and acutenefs, the papillæ, fituated on its apex and edges, appear to be brought into a ftate of genuine, though flight, erection.

SECT. XIX.

OF SMELLING.

§ 238.

By means of the fenfe of fmelling we perceive impreffions made by the odorous effluvia of fubftances, which being inhaled in infpiration, come in contact with that part, in particular, of the Schneiderian membrane, which invefts each fide of the feptum narium, and lines the convex furfaces of the concha.

§ 239.

For although the whole of the internal nares, together with the adjoining finufes, which open into them, be lined with a humid membrane, fimilar in appearance to the Schneiderian, it neverthelefs appears to be diverfied in its nature in different places.

That part of the membrane, which is fituated near the opening of the external nares themfelves, bearing

bearing a ſtronger reſemblance to the other parts of the real cutis, is overſpread with ſebaceous follicles, which are completely mantled in cluſters of hair.

But that part which lines the *ſeptum narium*, and *conchæ*, is of a fungous nature, and abounds with ſmall muciferous cryptæ or cells.

Finally, Thoſe portions which inveſt the *parietes* of the frontal, the ſphenoidal, the ethmoidal, and the maxillary ſinuſes, are by far the moſt tender and delicate of all, and are completely overſpread with an infinitude of minute blood-veſſels, which conſtantly exhale from their extremities a ſubtle dew-like fluid of an aqueous nature.

§ 240.

The principal, if not, indeed, the only uſe of thoſe *ſinuſes* appears, therefore, to be, to furniſh a watery liquid, of ſuch a nature, as has been juſt deſcribed, which being firſt conveyed into the three paſſages or avenues of the nares, may be from thence communicated to thoſe adjacent parts, which, we have already ſaid, conſtitute the immediate inſtruments of the ſenſe of ſmelling. By thus ſupplying, with a due degree of humidity, the parts which proximately form the olfactory organs,

organs, thoſe ſinuſes contribute, not a little, to preſerve the acuteneſs and perfection of this intereſting ſenſe.

For the attainment of this end, ſuch a wiſe proviſion is made by the very ſituation of thoſe ſeveral ſinuſes, that in whatever poſition the head be ſuffered to reſt, one or other of them may ſtill diſcharge and depoſit a quantity of this ſubtle dew, on the immediate ſeat of the ſenſe of ſmelling.

§ 241.

The fungous part of the naſal membrane, of which we have already ſpoken, and which conſtitutes the proximate organ of ſmelling, beſides, the immenſe number of minute blood-veſſels with which it is overſpread (and which are rendered in a particular manner remarkable, by this circumſtance, that there are no other veſſels in the whole body equally liable to ſpontaneous hemorrhages); beſides theſe ſmall blood-veſſels, I ſay, this part of the membrane is alſo furniſhed with nerves, eſpecially from the firſt pair, and alſo from both branches of the fifth pair: of theſe, the firſt pair appears to be of itſelf ſolely ſubſervient to the ſenſe of ſmelling; while the others ſupply the parts, to which they are diſtributed, with branches for the purpoſes of *common ſenſation*, ſuch, for example, as that which gives riſe to ſneezing, &c.

§ 242.

§ 242.

The extreme filaments of this firſt pair of nerves are not, (as is the caſe in the organs of touch and taſte), lengthened out and rounded into papillary elongations, but appear to deliquate, or melt down, as it were, into the ſpongy and uniform parenchyma of the membrane in which they terminate.

§ 243.

In new-born infants, the chamber deſtined for the immediate reception of odours is narrow, and as yet extremely imperfect. The ſinuſes, of which we have already ſpoken, have at this time ſcarcely made their appearance: hence, infants do not acquire the ſenſe of ſmelling till a late period, as the expanſion and complete formation of their *internal nares* are but gradually and very ſlowly accompliſhed. The larger thoſe inſtruments become, and the more accurately they are formed and finiſhed, the more exquiſite will be the acuteneſs and perfection of this ſenſe.

§ 244.

Finally, it is a truth well worthy of being remembered, that there is ſcarcely another external ſenſe, which poſſeſſes ſuch a powerful connection with, and influence over, both the ſenſorium itſelf, and the internal ſenſes, as that of *ſmelling*.

There

There is none fubject to fuch ftriking diofyncrafies; none better calculated either to produce, to prevent, or to remove, paroxyfms of fainting.

Neither is there any one fufceptible of more delicate and pleafing impreffions; the *fmell* is, therefore, happily termed by Rouffeau *the fenfe of the imagination.*

Nor are there, laftly, any other fpecies of fenfations that appear to excite fo clear and vivid a remembrance, as that which fpecific odours recal to the memory.

SECT. XX.

OF HEARING.

§ 244.

SOUND, which is excited by a tremulous collifion of elaftic fubftances, and propagated from fonorous bodies, through the medium of the air, is at length perceived by the fenfe of *hearing*, after having proceeded onward in the following order: viz. it is firft received by a fhell-formed cartilage denominated the *external ear*, over which

a few

a few of the human ſpecies poſſeſs a power of voluntary motion: being collected and concentrated, as it were, by means of this *concha* or *ſhell*, it paſſes immediately into the *meatus auditorius*, which is thoroughly anointed and defended by a very bitter and ſomewhat yellowiſh cerumen, or wax-like ſubſtance: at the internal extremity of this meatus auditorius it ſtrikes againſt the *membrana tympani*, which is ſituated in an oblique poſition, is firmly attached to an annular groove in the *os temporis*, and forms a complete partition between this meatus auditorius, or paſſage for ſound, and the middle portion of the ear.

§ 246.

Behind this membrane, the middle portion of the ear, denominated the *cavity of the tympanum*, is ſo ſituated as to have its fundus or bottom pointing upwards and inwards.

It contains three *ſmall bones*, belonging to the organ of *hearing*, the external of which, called the *malleus*, is connected by its handle to the membrane of the tympanum; from its *ſpinous proceſs*, which runs in a forward direction, a bulb or globe is formed, (eſpecially in an adult ſubject), with an annular groove ſurrounding its baſe; this ſmall globular head reſts on the body of the *incus*.

The

The incus itſelf is attached to the minute knob or head of the *ſtapes*, by its longer proceſs, which extends nearly to the middle of the cavity of the tympanum.

Finally, the *ſtapes*, reſting its baſis on the *feneſtra ovalis*, looks towards the *veſtibulum* of the labyrinth, into which, ſound, having percuſſated againſt the membrane of the tympanum, is propagated by means of the connections of thoſe three *oſiccula* or ſmall bones.

§ 247.

The Euſtachean tube, running from the interior parts of the fauces, opens alſo into the cavity of the tympanum; the inferior winding paſſage of the *cochlea* enters likewiſe into the ſame cavity; over the mouth or orifice of this paſſage, called the *feneſtra rotunda*, a fine membrane of a peculiar nature is expanded. Phyſiologiſts have not yet aſcertained and demonſtrated, in a clear and ſatiſfactory manner, the uſes of either of thoſe two laſt mentioned parts.

§ 248.

Laſtly, in the deep and hidden receſſes of the *os petroſum* lies the *labyrinth*, or *internal portion of the ear*, which embraces again three ſeveral parts.

Theſe

Theſe are the *veſtibulum*, which is ſituated in the middle between the other two, and into which open, beſides the feneſtra ovalis, both the five mouths of the *ſemicircular canals* that run in a backward direction, and alſo the ſuperior winding paſſage of the *cochlea*, which extends and lies anteriorly.

§ 249.

The labyrinth itſelf contains a very ſubtle, limpid water, which has been named after the illuſtrious Cotunnius, and which that celebrated phyſiologiſt diſcovered to be abſorbed by two very minute canals: theſe ſmall canals, called by Cotunnius, aqueducts, (and by Meckel *diverticula*), ariſe, the one from the veſtibulum itſelf, the other from the inferior winding paſſage of the cochlea.

§ 250.

The ſoft portion of the ſeventh pair of nerves, together with the hard, (which afterwards paſſes through the *aqueduct* of Fallopius), having entered the internal chamber of hearing, tranſmits its medullary filaments through the perforated bottom of that cavity. Theſe filaments paſs, in part, to the veſtibulum and ſemicircular canals, but are diſtributed more eſpecially over the baſe of the cochlea, where their extremities are arranged in ſuch a manner as to run between the

2 laminæ

laminæ or plates of the ſeptum of the cochlea, exhibiting the appearance of a fine medullary zone, beautifully ornamented with plexiform ſtriæ or ſtreaks.

§ 251.

The oſcillatory tremor which we formerly traced and followed up, even to the feneſtra ovalis, (§ 246.), is from thence propagated to the veſtibulum, where, finally, through the medium of the ſubtle aqueous liquid already deſcribed (§ 249.), it ſtrikes and impreſſes the auditory nerves themſelves, which are diſtributed with infinite art and ingenuity throughout the mazy circumvolutions of the labyrinth.

§ 252.

The impetus of ſound, ſtriking againſt the *membrane*, and being propagated through the *cavity* of the tympanum, is thought to be modified and regulated, not only by the muſcles of the *malleus* and *ſtapes*, which appear, in their contraction and relaxation to be ſubject to the influence of the will, but alſo by the *chorda tympani*, which is ſituated in the middle, between the handle of the malleus and the longer leg of the *incus*.

SECT. XXI.

OF VISION.

§ 253.

THOSE rolling or verfatile globes, denominated eyes, are to be confidered as the immediate inftruments of the fublime fenfe of *vifion.* They are fixed as if on footftalks, by their optic nerves (refpecting the decuffation of which we have already fpoken, § 205.), in fuch a manner, that their infertions are not directly oppofite to the centres of the cornea and iris, but are placed behind the imaginary axes of the eyes, in fituations fomewhat nearer to the nofe.

§ 254.

Each orb is compofed of various tunics or coats, which inclofe humours of different denfities, and fo extremely pellucid, that the rays of light, having entered the pupil or window in the anterior fegment of the orb, can pafs through, without the leaft interruption, to its bottom or oppofite fide.

§ 255.

The external involucrum of the globe of the eye is called *fclerotica*, the anterior *hiatus* or chafm of which

which is closed up by the transparent *cornea*, which is a lamellated membrane, more or less convex, and projects in a slight degree forward, like a segment of a smaller globe protruding out of a larger.

§ 256.

Next to the sclerotica lies the *tunica choroidea*, which abounds in blood-vessels, more especially in verticose or circuitous veins: this coat is stained on each side by a black pigment, which loosely adheres to its concave surface after the manner, and with the appearance, of mucus.

§ 257.

The choroides encloses, finally, the *retina*, which is the most internal of the common tunics embracing the visual orb. This coat consists entirely of the medullary substance of the optic nerve, which having perforated the sclerotica and and choroidea, is expanded on the concave surface of this last involucrum, and there arranged with the utmost beauty and elegance of structure.

§ 258.

The anterior border of the tunica choroidea terminates in a cellular ring, which is denominated *orbiculus ciliaris*, and by means of which the choroides is more firmly attached to a corresponding

groove or depreſſion in the ſclerotica. From this cellular girdle or attachment, two other membranes of different kinds, (namely, the *iris* and *ciliary proceſſes*), originate and diverge from each other, like two expanded circles.

§ 259.

The *iris* (the poſterior ſurface of which, being overſpread with a dark pigment, is denominated *uvea*) is ſituated anteriorly, is gently convex on the ſurface next the cornea, and is ſurrounded on all ſides by a humour of an aqueous nature. That ſegment of the iris, which lies next the noſe is narrower, while that which looks towards the temples is poſſeſſed of greater expanſion. Its texture conſiſts entirely of condenſed cellular membrane, without the ſmalleſt veſtige of muſcular fibres; upon the whole, it appears to be in reality a membrane *ſui generis*, as was formerly well obſerved by Zinn, and not by any means an appendage to the choroides. On its anterior ſurface it is differently coloured in different individuals, and while diſtended and animated with a plenitude of life, it exhibits ſomewhat of a floccoſe appearance.

§ 260.

The blood-veſſels of the iris run principally on its anterior ſurface, and, in the fœtus, are continued

tinued into what is called the *membrana pupillaris*: refpecting the nature and ufe of this membrane, I have fpoken more fully in another place *. It appears to be intended for the purpofe of preferving the iris, (during the rapid growth of the ball of the eye), in a ftate of expanfion, and thus rendering it more fit for future motion.

About the feventh or eighth month of pregnancy, when the ball of the eye has now acquired a confiderable magnitude, this membrane begins to open and give way in its centre; the elliptical arches of its veffels are retracted in a very gradual manner, and thus form, in my opinion, the *fmall interior ring of the iris*; it is, at leaft, certain, that not a fingle trait of this ring can be difcovered in the eyes of a fœtus previoufly to the above-mentioned period.

§ 261.

The *pofterior* of thofe two orbicular membranes, of which we have already fpoken, (§ 258) is called the *ciliary body* or *band;* it runs in a backward direction, and therefore, in its progrefs, diverges ftill farther from the iris; by its *external border*, which is grofs and firm, it is attached to the *orbiculis ciliaris* (§ 258), but by its *internal*,

* Commentat. fociet. fcient. Goettingens. T. VII.

which is more fine and delicate, it embraces the margin of the capfule of the lens: it is alfo fhaded with that fame dufky pigment, of which we have twice already fpoken.

Its anterior furface, lying oppofed to the uvea, is fomewhat ftriated.

Its pofterior furface, refting on the vitreous fubftance, is diftinguifhed by about feventy plicæ or folds, which exhibit an extremely elegant floccofe appearance; thefe are called *ciliary proceffes*, and are remarkable for a vafcular apparatus of inexpreffible fubtlety and beauty.

§ 262.

In the eye-ball itfelf, the membranes of which we have been hitherto defcribing, there are enclofed, in particular, three different *humours*.

The *vitreous* humour occupies and fills the pofterior, and by far, the greateft, portion of the vifual orb. It is diftributed, in a countlefs number of minute drops, throughout as many minute cells of the *membrana hyaloidea*, in fuch a manner, that the whole mafs, confifting, in part, of membrane, and in part, of lymph, exhibits the appearance of a peculiar, tremulous jelly.

§ 263.

263.

The anterior part of this vitreous ſubſtance, has appended to itſelf, and embraces, in the *ciliary girdle*, a capſule, in which is contained the *chryſtaline lens*, ſurrounded on all ſides by a very ſubtle water, firſt diſcovered and deſcribed by Morgagni.

This lens itſelf, is alſo compoſed of extremely pellucid cellular membrane; it is by far more denſe than the vitreous ſubſtance, and is furniſhed with ſo minute a quantity of genuine humour, that, when preſſed between the fingers, it reſembles glue of the moſt tenacious conſiſtence, but at the ſame time of aſtoniſhing tranſparency.

§ 264.

The remaining portion of the internal cavity of the eye, is filled up by an exceedingly limpid *aqueous humour*, and, by the expanded orbicular curtain of the iris, is divided into two *chambers:* theſe are, the anterior, or more capacious chamber, which ſeparates the cornea from the iris, and the poſterior one, of ſmaller dimenſions, extending from the uvea to the *corpus ciliare*.

§ 265.

Theſe moſt precious and ineſtimable parts of the body, as Pliny, the elder, has emphatically

called the eyes, are ſecurely protected from external injuries, as well by their recluſe ſituations in their orbits, as by their valviform coverings, the *palpebræ*.

Between the folds of the *palpebræ* are planted, in immenſe profuſion, the crouded ſebaceous follicles of Meibomius; their *extreme* or *lower* edges, fringed with three or four phalanges of *cilia* or laſhes, are kept in an expanded ſtate by certain cartilages called *tarſi*, which are alſo of further ſervice in facilitating the motion of the palpebræ on the eye-balls.

But (to adopt the language of the eloquent Cicero) the parts ſituated immediately above the palbebræ, being cloſely mantled in the *ſupercilia* or *eye-brows* intercept and turn aſide the ſweat flowing down in ſtreamlets from the head and face, and alſo ſerve to moderate, in a certain degree, the exceſſive effulgence of light.

§ 266.

For the purpoſes of lubricating the eyes, of preſerving their ſplendor, and of waſhing out heterogeneous ſubſtances, *the tears* are provided: the principal ſource of this fluid is a ſmall conglomerate gland, deeply ſituated in a depreſſion towards the external part of the circumference of

the

the orbit. The excretory ducts belonging to this gland are numerous, but extremely tender; they are supposed to convey, from both eyes, in the course of twenty-four hours, about two ounces of tears; After having been excreted, the tears are again absorbed by the *puncta lacrymalia*, from whence they are conducted through what are called the *cornua limacum*, or *snail's horns*, to the lachrymal sac, and from thence finally discharged into the lowermost passage of the nares.

§ 267.

Thus much it was necessary to premise respecting the admirable structure of the visual organ. We come now to treat of the functions of this organ, or, in other words, to consider the *doctrine* of vision.

All the rays of light which fall on the convex surface of the cornea pass through it, provided their angle of incidence be less than that of 48 degrees. In consequence, not only of the density, but also the figure of the aqueous humour, the rays are refracted in that medium, and turned a little nearer to the real axis.

As many of the rays as, having passed through the pupil, enter the crystalline lens, must necessarily

farily, in this more denfe medium, be fubjected to a ftill higher degree of refraction.

But by means of the more attenuated and lefs refractive vitreous medium, wife provifion is made to prevent thefe rays from uniting in a focal point at too fhort a diftance: this point, being thus farther removed from the convex furface of the cornea, falls on the *retina*, and there exhibits, in an inverted pofition, the images of all objects prefented, and that in perfect correfpondence to the nature of furrounding and attendant circumftances.

§ 268.

This difference in the denfity of the refracting media of the eye, exhibits a very ftriking inftance of the exquifite and inimitable workmanfhip of the divine creator. By means of this diverfity, fuch a complete remedy is provided againft the two-fold feparation or divergency of the rays of light, (the one arifing from the different refrangibility of the different coloured rays, the other from the very figure of the lenfes), that they are all finally collected and united in the fame focal point.

§ 269.

The celebrated problem, in which the caufe is demanded, wherefore we fee thofe objects erect, the

the images of which are neverthelefs exhibited in an inverted pofition on the retina? appears to admit of an eafy folution, when we confider, that objects are faid to be inverted, only from the relation they bear to others, which are exhibited in an erect pofition.

In as much then as the images, not of a few, but of all objects, even of our own bodies, are received by the retina in the fame relative pofition, the fituations and relations of the whole of them harmonize and correfpond to one another, equally as well, as they could poffibly have done, had their pofitions been truly erect: in confequence of this, the mind, (which does not attend to the image itfelf, but to the fenfation excited by its impreffion), is fufficiently guarded againft embarraffment and miftake.

§ 270.

In as much as the conditions, effentially neceffary for the purpofes of acute and diftinct vifion, are extremely numerous and varied, the creator of man has made the wifeft provifion for thefe, by endowing the part, fubfervient to this fublime fenfe, with a great variety of functions.

As a certain *adequate*, but yet *definite*, quantity, and not too potent a *glare*, of light, is effential to

to the exiſtence of clear and perfect viſion, a two-fold caution is thus taken; firſt, to admit, (according as the light is ſtronger or weaker), a greater or leſs column of rays to fall on the lens; and ſecondly, that all ſuperfluous rays which enter the eye, and tend only to dazzle by the intenſity of their ſplendour, be abſorbed and rendered inactive.

The former of theſe purpoſes is effectually accompliſhed by the motion of the iris; the latter, by means of the black pigment.

§ 271.

The iris poſſeſſes an aſtoniſhing mobility, by which it accommodates itſelf ſo perfectly to the quantity of light acting on it, that when expoſed to a more intenſe glare, it is immediately expanded, and thus diminiſhes the ſize of the pupil, but when ſubjected to the action of a weaker light, it is again retracted, and the pupil conſequently enlarged.

Phyſiologiſts have attempted a ſatisfactory explanation of this motion, in a variety of modes, founded on different principles; by ſome it has been derived from diverſified impulſes of the blood on the tender veſſels of the moving part, while others have figured to themſelves the exiſtence of certain

certain imaginary mufcles in the *iris*, and have committed to them the whole of the phenomenon in queftion, &c. But I have lately made it appear in a feparate paper, that neither of thefe modes of explanation is well founded, but that it is much more agreeable to evidence, and correfpondent to the phenomena of nature, to derive the immediate caufe of the motion of the iris from its *vita propria*, or *fpecific life*. (§ 47.) The more remote caufe of this motion, as we obferved on a former occafion (§ 256), cannot be referred to any other fource, than the re-action of the fenforium itfelf.

§ 272.

The function of this dufky pigment, of which we have already fo repeatedly fpoken (§ 256, 259, 261,) to wit, that it is deftined to abforb the fuperfluous rays of light, and is hence of the utmoft importance in the bufinefs of perfect vifion, may, befides other arguments, be fafely inferred from diffections of the eyes of various animals; but is more completely demonftrated and eftablifhed, by the morbid conftitution of the white Æthiopians, or *Albinos*, as they are called, in whom, from a deficiency of this pigment, the organs of vifion are painfully tender, and the impulfe of light confequently too powerful to be borne.

§ 273.

§ 273.

It is further requifite, that the focus of refracted rays be perfectly formed on the retina, fo that it may ftrike the very *point* of vifion, and be neither fo far extended as to fall behind it, nor fo much contracted as to terminate before it, in the vitreous fubftance.

The latter of thefe deviations from perfect vifion is what takes place in thofe individuals called *myopes*, in whom the lucid cornea is rather too convex and gibbous.

But the former deviation is that under which the *prefbytæ* labour, as the conformation of the anterior parts of the eyes is directly the reverfe.

§ 274.

But as an eye perfectly found is able to difcern, with equal diftinctnefs, bodies, whether at a greater or lefs diftance, it muft, without doubt, be furnifhed with peculiar faculties or powers of accommodating itfelf to the various diftances of objects. That thefe internal and accommodating changes of the eye, are in a great meafure produced by the preffure of the *recti* mufcles on the ball which they embrace, is a pofition fo clear, and apparently well founded, as fcarcely to admit of a doubt. Befides other arguments which might be

be advanced in favour of this opinion, I am induced to adopt it in confideration of the very fingular ftructure, and extreme flexility, of the *fclerotica*, in the eye of the Greenland phoca, or fea-calf. By this peculiarity of fabrication and arrangement, nature has made the moft exquifite provifion to enable this amphibious animal to enjoy at all times, the advantages of vifion, though paffing its life alternately in media of very different denfities.

§ 275.

By means of thefe fame mufcles, our eyes, whilft we are awake, are perpetually agitated, although with an almoft infenfible motion, and fo directed as to have their vifual axes arranged in right lines with the objects viewed. For although the whole of the retina be poffeffed of fenfibility, yet it is not in every part equally well adapted to receive the images of objects.

For at the genuine axis of the eye-ball, in the place, for example, where the optic nerve enters, it appears, from the well-known and celebrated experiment of Mariotte, that the human eye is deftitute of the power of vifion.

But the *principal focus* of the retina, and that which ought to be confidered as the leading and

immediate inſtrument of diſtinct viſion, is ſituated in an imaginary axis of the eye-ball, which is ſuppoſed to paſs through the centre of the cornea, and to be thus continued through the centre of the whole orb. It is not, however, (as was lately obſerved by the celebrated Kæſtner in his comments on certain works of Boerhaave), to be from hence underſtood, that we are unable to ſee clearly and diſtinctly, more than one ſingle point of an object while the eye remains perfectly at reſt, and that we are obliged to ſhift or alter its axis in order to diſtinguiſh any other point. The caſe is quite otherwiſe, becauſe the ſenſation produced by one entire object, is alſo itſelf, like its original, or exciting cauſe, one and entire.

§ 276.

The habit of directing the axis of the eye with diſpatch and facility towards the object of viſion, is finally acquired only by uſe and daily exerciſe. That this is a poſition founded in truth, is demonſtrated not only by the example of ſuch individuals as, having been born blind, acquired afterwards the power of viſion in adult age, but alſo by that of tender infants, who ſeldom attain to this happy facility of moving their eyes previouſly to the third month after birth.*

§ 277.

To the ſame power of cuſtom and habit, muſt we alſo attribute the remarkable circumſtance of our ſeeing objects only ſingle, though our eyes be two in number. New-born infants appear to ſee objects double, and double viſion, which frequently continues ſometime after certain diſeaſes of the eyes, may be at length overcome and removed by uſe and exerciſe.

§ 278.

The *joint power* of both eyes, with regard to the *acumen* and ſtrength of viſion, does not, according to the calculation of Jurin, exceed that of one eye, more than a thirteenth part.

And, agreeably to an obſervation, long ſince made by that celebrated painter Leon. da Vinci, it is much beſt in judging of the diſtances of objects to make uſe of one eye only.

§ 279.

Finally, In treating of the ſtrength and perfection of the eye, our former illuſtrious countryman, Tob. Mayer, demonſtrated, by a ſeries of very elegant and ingenious experiments, that the angle of viſion ought to exceed, in dimenſions, at leaſt 34 *ſeconds* of a degree. From hence he at the ſame time illuſtrated and proved the extreme

 perfection

perfection of the human eye, because this extent of the angle of vision may continue nearly the same, under any light whatever, whether that of the meridian sun, or that of a weak lamp, so that though the window or pupil of the eye be greatly contracted and diminished, yet the clearness of vision can, from that source, be scarcely in any degree affected.

§ 280.

From hence we may infer, the inconceivable smallness of the images of objects which are thrown and delineated on the retina, and which are nevertheless impressed with so much force, that, under certain circumstances, vestiges of them remain a considerable time, even after the objects themselves have been entirely removed from the eye.

SECT.

SECT. XXII.

OF THE INTERNAL SENSES, AND OTHER FACULTIES OF THE MIND.

§ 281

THROUGH the medium of thoſe external ſenſes, of which we have hitherto treated, ideas are conveyed to our nobler part, *the mind;* for, agreeably to the tenor and ſpirit of a well-known theorem, nothing can enter the underſtanding ſave by the route or avenue of the ſenſes.

§ 282.

For the purpoſes of receiving and preſerving the ideas thus acquired, by the aid of the ſenſes, and alſo for making the beſt uſe and improvement of the intellectual ſtock received, various faculties of the mind contribute their united exertions. Though theſe faculties be, (as we have already had occaſion to obſerve, § 42.), widely different from the vital energies which reſide in the body, nevertheleſs, by means of the nervous ſyſtem, they are ſo cloſely connected with thoſe corporeal energies, that an aſtoniſhing intercourſe is thus eſtabliſhed and ſupported between the body and mind, (§ 211.)

§ 283.

The firſt of thoſe powers, poſſeſſing indeed, apparently, the loweſt grade, is the faculty of *perception*, by means of which the mind is rendered conſcious of impreſſions made on the different organs of ſenſe.

§ 284.

This faculty is aided by another, of better rank and higher dignity, namely, *attention*, which ſo directs and determines the mind towards any idea when once excited, as to rivet its thoughts to that object alone.

§ 285.

For the important purpoſes of preſerving ideas, which have been already perceived, of re-exciting them, and aſſociating them into more lively and picturesque ſpecies of imagery, two other faculties, called *internal ſenſes*, are brought into action: theſe are *memory* and *imagination*, two powers, which, though nearly allied to each other, may, notwithſtanding, be readily diſtinguiſhed by the following characters: *memory* appears to be more ſubſervient to, and engaged in, the reception and retention of *arbitrary ſigns* of things; whereas, *imagination*, on the contrary, wakes up rather the *very images* of things, beſtows on them form and colouring, and marſhals them under the view of the

the mind, as if the objects themselves were again actually present: this faculty is more particularly and powerfully exercised on such objects as are calculated to excite sensations of pleasure or disgust.

§ 286.

Upon the whole, the *faculty* of *choosing* and *refusing*, and, (when we consider the matter a little more minutely), even the foundation of the whole *will* itself, appear to rest and depend entirely on certain agreeable and disagreeable varieties of sensation.

§ 287.

From the same prolific source, namely, the *imagination*, are also to be derived the *affections* or *commotions* of the mind, to which we see different individuals variously subjected, in conformity to the countless diversities of existing temperaments (§ 59.) The very intimate and instantaneous consent of these affections with certain functions of the body, appears strikingly evident in an infinitude of examples; thus, for instance, there is scarcely a single passion of the mind, which does not possess considerable influence over the *motion* of the heart, the *appetite* for food, and the powers of *digestion*,—not to descend to a minute specification of particular effects, such, for example, as the action of shame in giving rise to

 blushing,

blufhing, the action of love or hatred on the *organs* which ferve to diftinguifh the fexes, the action of anger on the *fecretion* of bile, &c. &c.

While fpeaking of the effects produced in the economy of the human body, by the commotions of the mind, it is proper to obferve, that they may be divided into *ftimulant* and *fedative*, or into thofe which *excite*, and thofe which *deprefs*.

Of the former defcription are joy, love, hope, anger, &c.

Of the latter, fear, forrow, noftalgia, and other fpecies of permanent defire or longing, terror, envy, &c.

§ 288.

Thofe faculties of the mind hitherto enumerated, are obferved to exift in brutes as well as man, though the latter undoubtedly poffeffes them in by far the higheft degrees of ftrength and perfection: thus, for example, in none of the inferior animals do we difcover a memory fo extenfive in its range, and fo powerful in its tenacity; in none do we difcover fuch a fplendid brilliancy, and glowing warmth of imagination; in none do we difcover fuch an unbounded, and fometimes fatal, vehemence of mental paffions, &c.

§ 289.

§ 289.

The leading prerogative of the human mind, confifts in this, that it alone poffeffes the exclufive power of *reafon*, by means of which it is able to judge, to form abftract ideas, &c. and which exerts alfo the greateft influence over moft of the other faculties of the mind. In place of this divine power, other animals are endowed with various *inftincts*, or blind and involuntary *impulfes*, which lead them to the performance of fuch actions, as are fuitable to their feveral economies and modes of life. Of thefe inftinctive impulfes man, on the other hand, is furnifhed with fcarcely any, fave that which prompts him to participate in venereal gratifications.

§ 290.

The immenfe and ftriking difference between *animal inftinct* and *human reafon*, will appear glaring as the noon-day light to him who confiders:

That inftincts are faculties co-eval with birth, whereas, on the other hand, the ufe of reafon is acquired only by culture and education :

That inftincts remain ftationary, and admit of no improvement, whereas the expanfive improvement and exercife of reafon, are literally free from circumfcription :

That inſtincts are ſuited only to the deſtined mode of life, to the climate, &c. of each ſpecies of animals, and, on this account, are not adequate to the exigencies of man, who, confined to no climate, excluſively reſtricted to no mode of life, is deſtined to be an inhabitant of the world at large: from which boundleſs and ſplendid prerogative, an inconceivable diverſity of wants ariſe, which ſimple inſtinct is too weak!—far too weak to ſupply! but which, the powers of reaſon, from reſources equally diverſified as the emergencies themſelves, are able to ſatisfy, in the moſt ample and complete manner.

Laſtly, another high prerogative of man, depending on the powers and exerciſe of his reaſon, is the uſe of ſpeech, of which we have briefly ſpoken on a former occaſion (§ 154.) This invaluable privilege is the excluſive boaſt of man alone, brutes being only furniſhed with voice, or a power of emitting ſound.

SECT.

SECT. XXIII.

OF THOSE ACTIONS OF THE BODY WHICH ARE SUBJECT TO THE POWER OF THE WILL.

§ 291.

THE nerves, as we have already ſeen, are ſo conſtituted as to perform two different functions (§ 215), namely, *ſenſation* and *motion*. The doctrine of the former we have already conſidered. It yet remains to add a few obſervations on the ſubject of the latter.

§ 292.

The motions in general of the ſeveral parts of the human body, are uſually divided into two claſſes, one of which is excited and governed by the *power* of the *will*, while the other is not in any meaſure ſubject to its *influence*, or controul.

For examples of the latter claſs, phyſiologiſts commonly refer to the harmonious action of the heart, and likewiſe to the periſtaltic motion of the inteſtines and certain other viſcera, &c.

Inſtances

Inftances of the former clafs we have in the motions of by far the greater part of the other mufcles of the body.

Doubts are ftill entertained, with refpect to the real nature of certain motions which take place in the human fyftem; fuch as the motions in refpiration, in fneezing, in the tenfion of the *membrana tympani*, &c. Thefe are by fome claffed with the voluntary, by others with the involuntary, while others again refer them to a third clafs, called *mixed motions*.

§ 293.

When this divifion, however, is confidered with a little more fteadinefs and attention, it is eafily perceived to be embarraffed with fuch momentous difficulties, that it is fcarcely poffible to afcertain, and mark, with definitude, the precife limits between the claffes.

For, on the one hand, a few of the functions of our bodies, over which the will, unaffifted by other powers, may be faid to poffefs no command at all, may notwithftanding be excited and brought into action, when the imagination and paffions of the mind act in concert with the will.

On

On the other hand there are not wanting inftances of mufcular functions, which, though naturally fubject to the immediate command of the will, have, notwithftanding, been rendered in a great meafure *involuntary*, by the plaftic power of *cuftom*, (the influence and energetic agency of which, on animal motions, are indeed of the utmoft moment and importance.)

§ 294.

Of this latter defcription are thofe kinds of mufcular motion, which, although at other times fubject to the controul of the will, yet, under certain circumftances, take place not only without the confcioufnefs, but even contrary to the inclination of the mind.

Thus, for example, we wink *contrary* to our determination, when the finger of a friend is haftily approached towards our eye, although it does not touch it; and in moft perfons, the flexion of the little finger is ufually attended with a fynchronous flexion of the ring finger, though a determination had been formed to preferve the latter entirely unbent.

Without the *confcioufnefs* of the mind we frequently move our limbs, even when wrapt in the moft profound fleep.

There

There are, on the other hand, examples of mufcles, which, although for the moft part perfectly obedient to the will, yet in certain cafes refufe to obey its commands. To this head we may refer the difficulty of defcribing, by fynchronous movements, circles in contrary directions, with the hand and foot of the fame fide, together with other motions of a fimilar nature, which, although truly voluntary, and extremely eafy when practifed alone, are, notwithftanding, performed with the utmoft difficulty, if an attempt be made to affociate them with certain other motions.

§ 295.

With refpect to thofe motions, which phyfiologifts fuppofe to be perfectly exempt from the influence of the will, I know of none which can be clearly and unexceptionably referred to this head, fave the fpafms of the uterus in the labour of parturition.

With refpect to the pulfation of the heart, a very remarkable account ftands on record of a Britifh colonel, who poffeffed a power of fufpending, at pleafure, the motion of both the heart and arteries. In confirmation of the truth of this, we have the public teftimony of Baynard and Cheyne, two phyficians of the higheft reputation and

and veracity, who were themſelves witneſſes to the aſtoniſhing phenomenon.

That the motion of the ſtomach may be voluntary, (as indeed the proceſs of rumination in general ſeems to evince), I had once an opportunity of aſcertaining, to my entire ſatisfaction, in a ruminating human ſubject, in whom this retrogade or reverted motion of the ſtomach, was under the moſt perfect ſubjection to the command of the will.

Although the motion of the iris be involuntary, in by far the greater part of the human race, I have, notwithſtanding, been favoured with an account, ſufficiently authenticated, of a man, who poſſeſſed a power of voluntary command over this membrane, in ſuch a manner, as to be able, by a very ſingular effort, to contract the pupil of the eye even in a weak and dull light.

There are indeed a great variety of motions, which, though generally performed without the influence of the mind, are nevertheleſs voluntary in certain individuals, eſpecially if a high degree of attention, and a vigorous effort of imagination be excited. Thus, I have known men, who were able at any moment, to produce and exhibit on themſelves a ſpaſmodic horripilation of the ſkin, and

and alſo to renew and completely revive in themſelves the ideas or perception of certain diſagreeable ſenſations.

§ 296.

Perhaps thoſe phenomena may be ſatisfactorily explained from the *re-action* of the *ſenſorium*, which appears to be indeed as powerfully excited by means of the imagination waking up and exhibiting before it, the *image* of an active ſtimulus, as by the *ſtimulus itſelf*, when impreſſing it by its actual preſence. There are indeed an infinitude of phenomena of the animal economy, which admirably correſpond to this explanation; as the various cauſes, for example, which excite erections of the male penis, &c.

§ 297.

With regard to voluntary motions in general, it may be proper finally to obſerve, that they are among the primary and leading characteriſtics which ſerve to diſtinguiſh the animal from the vegetable kingdom; for, as on the one hand, a *power* of *voluntary* motion is never obſerved to be poſſeſſed by any plant, ſo on the other, ſuch a power conſtitutes an eſſential attribute of even the moſt ſimple and imperfect genera of animals.

§ 298.

§ 298.

In our own fyftems, the voluntary motions furnifh the moft full and ftriking evidence, of that intimate and truly aftonifhing harmony, which fubfifts between the mind and the body. Of the exiftence of this harmony every one will be convinced, who confiders with attention, the amazing celerity with which fuch diverfied motions fucceed each other, in the fingers of an able and fkillful performer on the violin, or in our organs of fpeech, while we are engaged in converfation.

SECT. XXIV.

OF MUSCULAR MOTION.

§ 299.

THE immediate organs of by far the greater number of the motions of our bodies, are the mufcles, which conftitute the principal portion and bulk of what are called *partes fimilares*.

§ 300.

The mufcles are, however, diftinguifhed, in a particular manner, from the reft of the fimilar parts, by a two-fold characteriftic; *one* depending

on

on their texture; and the *other* of a very ſingular nature, derived from their vital energy.

§ 301.

Their texture is fleſhy, compoſed of a peculiar ſet of fibres, of a very pale red colour: they are ſo joined together, that every muſcle conſiſts, in the firſt place, of fibrous cords, theſe cords again, of ſmaller bundles of fibres, which bundles, by a ſtill further progreſſive diviſion, may be finally ſeparated and reſolved into fleſhy fibres and fibrils of inconceivable minuteneſs.

§ 302.

Each muſcle is incloſed in a cellular ſheath or covering, which, paſſing into the very ſubſtance of the muſcle, appears to be interwoven throughout the whole of its volume, and thus forms partitions, firſt between the larger *lacerti*, then between the ſmaller faſciculi or bundles, and laſtly, between the fibres and more minute fibrils themſelves.

§ 303.

Beſides this cellular expanſion, the whole texture of the muſcles is alſo interſperſed with an infinitude of blood-veſſels and nervous filaments; of theſe, the *latter* appear to deliquate into an inſcrutable pulp, and to be thus very intimately

blended along with the mufcular fibres; but the *former* are fo extenfively and minutely interwoven among thofe very tender fibres, as to paint the whole of the flefhy parts with that beautiful crimfon dye, by which they are uniformly characterifed. When thefe are thoroughly wafhed, they are again reftored to their native colour, which, as already obferved (§ 301.), is fomewhat pale.

§ 304.

Finally, a circumftance common to moft of the mufcles is, that they terminate in *tendons*—parts, which, though likewife of a fibrous texture, are notwithftanding fo extremely different, with refpect to colour, ftructure, elafticity, &c. that their entire difagreement from both the preceding kinds of fibres, is very eafily afcertained and demonftrated. Hence, therefore, we are enabled fuccefsfully to refute the opinion of thofe phyfiologifts, who have erroneoufly fuppofed, that the *tendinous*, are nothing more than mere continuations of the *mufcular* fibres. To the adoption of this opinion, they have been inadvertently led by attending to the following phenomenon, obfervable in the mufcles of infants; namely, if we compare the *mufcular parts*, of thefe tender fubjects, with *thofe* of adults, we will find the proportion of flefh, to that of tendon, greater in the former than in the latter.

§ 305.

The other exclusive characteristic of muscles, which we have mentioned (§ 300.) is, the *irritability* of Haller. Although we endeavoured, on a former occasion, to give a general view of this vital energy, and to ascertain the difference between it and *contractility*, (§ 44.), yet it may not be improper, at present, to pursue the inquiry a little further.

§ 306.

This irritability, otherwise called *vis muscularis*, *vis insita*, or *vis propria*, is indeed common to all the muscular parts of our bodies, but does not reside in all of them in the same degree, some parts being observed to possess a much higher proportion of it than others.

The principal seat of this energy, where it most plentifully abounds, is the hollow muscles, subservient to the vital and natural functions: of these muscles, the heart, as was observed formerly (§ 119.), possesses the highest degree of the *characteristic* now under consideration: of this last mentioned organ, the internal surface, in particular, is endowed with the most exalted degree of life, and is by far the most tenacious of irritability.

Next

Next to the heart, in point of this prerogative, is the inteſtinal canal, more eſpecially that portion of it which conſtitutes what are called the *ſmall inteſtines:* in warm-blooded animals, this part of the tube ſometimes contracts on being irritated, even after the heart itſelf has become incapable of motion.

Next in degree is the ſtomach,—next, the urinary bladder, &c.

Among the remaining muſcles of the ſyſtem, irritability reſides, again, in a very ſtriking degree, in thoſe actively concerned in the function of reſpiration, as the diaphragm, the intercoſtals, and the *triangularis ſterni.*

Next in order to theſe are the various other muſcles of the body.

The arteries doubtleſs poſſeſs irritability, though in a degree far inferior to what exiſts in the parts juſt mentioned (§ 123.)

This vital energy reſides alſo in the trunks of veins contained in the thorax, (§ 84.)

In a degree *ſtill lower*, does it exiſt, in the other parts of the ſanguiferous veins, if, indeed, thoſe

parts can be ſaid to poſſeſs any *genuine irritability* at all (§ 128.)

§ 307.

Haller himſelf, that illuſtrious defender of the doctrine now under conſideration, appears to me to have, without ſufficient foundation, attributed irritability to *certain parts* of the body, which are found, indeed, on experiment, to be endowed with *contractility* (§ 50 ſeq.), but in which I have never been able to diſcover any indubitable teſtimonies of genuine *irritability*.

Among theſe parts may be reckoned the lacteal veins, the ſmall glands, the gall-bladder, the uterus, the *dartos* covering, and the male penis.

On no better foundation, in my opinion, is irritability attributed, by others, to the iris, to the external ſurface of the lungs, &c. in all which parts (if, indeed, I be capable of judging rightly), there exiſts no more of this vital energy, than there does in the common cellular membrane, and parts compoſed of it, ſuch, for inſtance, as the common integuments, the meninges, the pleura, the peritoneum, the perioſteum, the medullary membrane, the tendons, the aponeuroſes, &c.; or than there does in thoſe viſcera compoſed of genuine *parenchyma*, (§ 27.), ſuch as the liver,

the

the ſpleen, the kidneys, the ſecundines, the brain, with the reſt of the nervous ſyſtem, &c. all which parts, as they are throughout, completely deſtitute of muſcular fibres, ſo are they likewiſe deſtitute of irritability, which reſides in muſcular fibres alone.

§ 308.

As we have, thus, on the one hand, ſeen muſcular *irritability* now and then confounded with cellular *contractility*, ſo on the other, certain celebrated characters have lately been deſirous of aſcertaining and eſtabliſhing an identity between *irritability* and the *vis nervea*.

For although we can neither deny the powerful influence of the nerves on *muſcular motion*, (of which we will ſpeak a few words preſently), nor exhibit the ſmalleſt fibril of muſcular fleſh, perfectly deſtitute of the pulp of evaneſcent nerves, yet theſe circumſtances are not ſufficiently momentuous to compel us to a dereliction of the opinion, that irritability is, in its own nature, as widely and eſſentially different from the *vis nervea* as it is from *contractility*. On the one hand, this energy is wanting in all parts not muſcular, although they be ſupplied with the utmoſt profuſion of nerves, as the ſkin, all the nervous viſcera, &c.; whereas, on the other, we are not able to produce any portion of true muſcular fleſh, where

the genuine and obvious phenomena of irritability do not exhibit themſelves. From a cloſe and impartial conſideration of the foregoing arguments, beſides a great number of others which might be advanced, it appears more conſonant to reaſon and ſound induction, to attribute the ſingular *phenomena* of irritability to the equally ſingular texture of muſcular fibres, than to refer them to the nerves, which, in ſo many other parts of the body, are as minutely diſtributed as they are through the muſcles, and yet do not generate and exhibit, in thoſe parts, the fainteſt ſhadow of real irritability. I ſay nothing of the weighty arguments which might be drawn from the following well-founded poſition, viz. that no ſteady proportional relation is obſerved to exiſt, between the degree of irritability in any part of the body, and the quantity of nerves with which it is ſupplied.

§ 309.

With reſpect to the extreme terminations of the nerves, which are well known to exert an influence over the muſcles, the following appears to be the moſt rational concluſion, viz. that they may be conſidered as *remote* or *exciting* cauſes of muſcular motion, but ſhould not be confounded with the *proximate* or *efficient* cauſe, which is indeed *irritability* alone, and that reſiding excluſively in the muſcular fibres.

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The paſſions of the mind, for example, act on the ſenſorium, this again re-acts on the nerves of the heart, in ſuch a manner, as to excite its irritability, and thus produce palpitations and other irregular motions of this organ.

The will acts on the ſenſorium, this re-acts again on the nerves of the arm, theſe nerves in like manner operate immediately as remote cauſes in exciting muſcular motion, which, notwithſtanding, depends ultimately for its exiſtence on irritability itſelf.

§ 310.

This diſtinction, of the two kinds of cauſes which concur in the production of muſcular motion, is indeed fully authoriſed and ſanctioned by actual experiments: from a variety of theſe it appears, that certain parts of the animal ſyſtem have been oftentimes rendered paralytic, by cutting, or incloſing in ligatures, the nerves leading to them, while they have, notwithſtanding, ſtill continued to retain their *irritability* for a long time afterwards.

§ 311.

In what degree the blood, with which the muſcles are very abundantly ſupplied, contributes to their action, is not yet clearly and ſatisfactorily aſcertained.

It appears, however, from an experiment of Steno, that a paralyſis of the lower extremities may be generally produced, by paſſing a ligature round the aorta in its deſcent behind the abdominal cavity.

§ 312.

Beſides theſe common inherent energies of the muſcles, which have hitherto been the ſubjects of our conſideration, they poſſeſs alſo certain ſpecific and adventitious peculiarities, ariſing from varieties in their figures, ſituations, &c. by theſe peculiarities they are adapted, and rendered completely adequate, to the nice performance of their ſeveral functions.

§ 313.

From the contemplation of this circumſtance, muſcles are uſually divided into hollow and ſolid: the former of theſe, as we have already ſeen, not being in immediate ſubjection to the command of the will, are particularly deſtined to the performance of the *vital* and *natural functions*, and cannot, therefore, be further treated of in this place, where we are conſidering what are called *voluntary* muſcles, which are more eſpecially ſubſervient to that order denominated the *animal functions*.

§ 314.

§ 314.

Between these last-mentioned muscles themselves, there occur again very striking diversities. For to say nothing of the varieties in their relative magnitudes, they differ extremely from each other in the disposition of their *lacerti* and *fasciculi*, in the direction of their fibres, but more especially in the habit and proportional relation of their fleshy and tendinous parts, and, finally in their courses, their insertions, &c.

§ 315.

Nevertheless, in by far the greater part of the *fusiform* or tapering muscles, their figures are more or less oblong, so that their fleshy bellies terminate at each end in tendinous cords. These cords, which are inert and perfectly destitute of irritability, being attached to, and inserted in, bones, serve the necessary purpose of moving them after the manner of levers.

§ 316.

As there are, however, a few muscles in the body entirely destitute of tendons, such as the *latissimus colli*; so there are, in like manner, a few not attached to bones, namely, the muscle last mentioned, the *cremaster muscle*, as it is generally called, the *azygos uvulæ*, and most of those which move the ball of the eye.

§ 317.

§ 317.

By the co-operation and combined aid of all thofe energies, (as well the common, § 305, as the proper, § 312), with which the mufcles are furnifhed thefe inftruments of motion are fitted and completely qualified for the performance of their feveral actions, which may, in like manner, be alfo divided into *common* and *proper*.

§ 318.

During their common action, which arifes immediately from irritability, and occurs in all mufcles, their flefhy portions become fhorter, more rigid, and, for the moft part, unevenly and fomewhat angular. It alfo appears from the celebrated experiment of Gliffon, that they fuffer at the fame time a flight diminution in point of magnitude.

We are indeed prevented from joining Jo. and Dan. Bernouille, and other mathematical phyficians, in an attempt to reduce the meafure of this diminution to common calculation, *firft*, by the immenfe difference in this refpect, which is obfervable between the hollow and folid mufcles, and *fecondly*, by the diverfity which alfo occurs, on the fame point, between thefe latter mufcles themfelves;—not to mention various other difficulties, which obftruct the road to fuccefs.

§ 319.

§ 319.

The proper or ſpecific actions of the muſcles, (§ 317.), correſpond preciſely to their ſpecific energies; from whence it naturally and ſpontaneouſly follows, that theſe actions are marked with ſuch an infinitude of varieties, as to render it literally impoſſible to reduce them to any general laws, or to arrange them under any well-defined *orders* and *genera.*

With regard to the general principle, commonly taught and adopted on this ſubject, viz. that every muſcle while in action, draws the more moveable part to which it is attached, towards that which is more permanent, it ought to be conſidered, (as has been very juſtly obſerved by the ſagacious Winſlow) in a relative point of view, and is indeed ſubject to a variety of limitations. Thus, for example, the two parts to which a muſcle is attached, may be rendered, each more moveable than the other, in alternate viciſſitudes, accordingly as the one or the other is fixed and rendered ſtationary, by the joint action of other co-operating muſcles.

As to the action of the flexor muſcles, it ought to be eſtimated on contrary principles, and a different opinion formed reſpecting it. Although theſe muſcles, for the moſt part, predominate ſo much over their antagoniſts, the *extenſors*, that when

when the body is in a ſtate of perfect quietude and reſt, the arms, fingers, &c. are under a gentle degree of flexion, yet theſe parts do not appear to be drawn into this ſtate and poſition by any actual force, but rather in conſequence of a voluntary relaxation of their extenſor muſcles, by means of which, thoſe muſcles, ſubſervient to the flexion of the parts, are left at liberty to act without oppoſiton or reſiſtance.

§ 320.

To all the foregoing conſiderations, it appears proper to add, in the laſt place, that each muſcle poſſeſſes a peculiar and ſpecific mechaniſm, by means of which it is adapted, in the moſt complete manner, to the performance of the various motions of its immediate deſtination.

Beſides the peculiar advantages which the muſcles ſeverally derive from their determinate figures, their actions are alſo promoted by a variety of other concomitant aids, ſuch, for inſtance, as the annular ligaments by which they are ſurrounded; the fat, in which a great number of them are imbedded; the lymphatic dew with which they all abound; and, what ought to have been mentioned in the very firſt inſtance, the conformation of the ſkeleton itſelf, eſpecially as far as the ſame relates to the ſtructure of the apophyſes, and the articulation

articulation of the joints: under the ſame head of auxiliaries to the muſcles, may be alſo arranged certain entire bones, as the *patellæ*, and oſſa ſeſimoidea, of ſimilar ſtructures and uſes, which nature appears to have very wiſely adapted and deſtined to facilitate the motions of particular muſcles.

321.

By theſe diverſified and numerous aids, has nature made compenſation for, or at leaſt very conſiderably diminiſhed, that inevitable loſs of power, which neceſſarily ariſes from the conformation and ſtature of the whole body. The acuteneſs of the angles formed by the inſertions of a great many muſcles, and the vicinity of theſe inſertions to the centres of motion, may be brought forward as incontrovertible teſtimonies in favour of ſuch a loſs of power, which would not have been ſuſtained, had the tendinous cords been inſerted at greater diſtances from the centres of motion, or in ſuch directions, as to have formed more obtuſe angles.

§ 322.

To our bodies, thus furniſhed with about four hundred and fifty muſcles, together with a few occaſional ſupernumeraries, (ariſing from ſexual and individual varieties), two advantages of the utmoſt magnitude and importance are very obviouſly

oufly derived. Firft, in confequence of this beautiful and complicated fyftem of organs, not only our individual members, but alfo our whole bodies, are rendered capable of the moft aftonifhing agility, in point of motion; and *fecondly*, from the fame fource, we derive fuch remarkable degrees of ftrength, as qualify us to bear, without injury, the moft arduous fpecies of labour and fatigue. Thefe two momentous advantages depend, indeed, in part, on a perfect ftate of the mufcles, to which, no lefs than to a perfect ftate of the bones, we arrive by degrees, as youth advances towards maturity; but they are alfo, in part acquired by a frequency of ufe and exercife. The powerful influence which thofe two latter circumftances poffefs and exert over the mufcles, in ftrengthening them and rendering them capable of the utmoft agility of motion, is ftrikingly demonftrated by numerous examples of rope-walkers, of dancers, of runners, of wreftlers, of boxers, and of thofe robuft barbarians, who conftituted the glory and boaft of former ages.

SECT.

SECT. XXV.

OF SLEEP.

§ 323.

THOSE two ſpecies of nervous action, (the hiſtory of which we have now completed) that have for their ultimate ends *ſenſation* and *motion*, are ſo reduced and debilitated by the diverſified exerciſes of the day, that repoſe by night becomes abſolutely neceſſary, for the purpoſe of refreſhing their declining vigour and energy, which *ſleep* alone, the image, or *ſemblance* of gelid death, is able completely to reſtore.

§ 324.

Sleep is a function perfectly periodical, which ſuſpends, as it were, for a time, all intercourſe and communication between the mind and body. The various phenomena of this function, ſome of which ſhall be immediately enumerated, appear to declare, with no ſmall force of evidence, in favour of the exiſtence of a nervous fluid.

§ 325.

Beſides a variety of other circumſtances, we may here enumerate as precurſors and harbingers of

of ſleep, a ſluggiſhneſs and gradually increaſing dullneſs of the external ſenſes, together with a relaxation of moſt of the voluntary muſcles, eſpecially ſuch as are of conſiderable length. To theſe may be added a congeſtion of the venous blood in, and near, the heart, and an effort to remove the uneaſineſs thence ariſing, by the aid of yawning. Finally, the only additional precurſor to be mentioned at preſent, which appears to conſtitute the very *iſthmus*, as it were, between the waking and ſleeping ſtates, and the immediate tranſition of the former into the latter, is a peculiar ſpecies of tranſient delirium.

§ 326.

The following are what conſtitute the principal phenomena of ſleep, when that ſtate has actually occurred: the *animal* functions are wholly ſuſpended from action, while almoſt all the *others* are at the ſame time performed in a more ſluggiſh and torpid manner; thus, in ſubjects buried in ſleep, all other circumſtances being alike, the pulſe is ſlower, and the heat of the body ſomewhat diminiſhed; perſpiration is alſo leſs plentiful; digeſtion leſs powerful; and (if the occaſional diſcharge of the ſemen maſculinum be excepted) all the excretions are ſuppreſſed, &c.

§ 327.

The *remote caufes* which induce fleep are very plain and obvious. For to fay nothing of narcotic fubftances themfelves, we may confider as very energetic caufes in the production of this ftate, all *wafte* of the *animal powers* by means of preceding *fatigue*, by *watching*, &c. To thefe we may fubjoin the influence of cuftom, together with darknefs, filence, reft, &c. which appear indeed to derive their fomniferous powers from the fame fource; we may alfo further add, gentle, uniform, and conftant impreffions acting on any of the fenfes, fuch, for inftance, as the foft murmurings of the rill, or the appearance of a harveft field, agitated and thrown into wavy undulations, by the mild fannings of the weftern breeze, &c. Under the fame head of remote caufes we may alfo confider, full meals, and intenfe cold acting on the body, together with a variety of other circumftances, tending to derive the blood from the encephalon, as pediluvia, clyfters, and profufe hemorrhages, &c.

§ 327.

Thofe remote caufes which we have mentioned in the latter part of the preceding paragraph, are, of themfelves, fufficient to conduct us to the *proximate caufe*, which appears, from the beft evidence

that can be collected on the fubject, to confift in a diminution of the column of blood that goes to fupply the encephalon.

That this is indeed the proximate caufe of fleep, is powerfully illuftrated and confirmed, by a very fingular and ftriking phenomenon, which I had once an opportunity of obferving in a living human fubject, whofe cafe has been already mentioned on another occafion. As often, and as long, as this perfon indulged himfelf in fleep, his brain fubfided and continued in a ftate of confiderable collapfe, but during his waking hours throughout the day, this organ became again turgid and diftended in confequence of a more copious afflux of blood.

As an additional argument in fupport of the fame *caufe*, we may obferve, that *morbid watchfulnefs*, on the other hand, ufually arifes from congeftions of blood in the region of the brain.

§ 329.

The quantity of fleep neceffary, depends in a great meafure on varieties in age, habit of body, temperament, &c. The general refult, however, of all the exifting evidences on this fubject, appears to be, that a longer indulgence in fleep is either a concomitant of imbecility (as is the cafe

in

in tender infants. and ſubjects far advanced in years), or a very exuberant ſource of fatuity and dullneſs.

§ 330.

We riſe from ſleep with renovated powers, and our return into the living, and completely waking ſtate, is accompanied with ſymptoms and phenomena very ſimilar to thoſe which attended our tranſition from this ſtate into that of ſleep: we are attacked, for inſtance, by a yawning, accompanied for the moſt part with more or leſs of a ſtretching, we are alſo affected by a certain dullneſs and torpidity of the ſenſes, &c.

§ 331.

The cauſes which rouſe into wakefulneſs, appear to correſpond exactly with thoſe productive of ſleep.

The proximate cauſe will be the return of a more copious column of blood into the encephalon.

The remote cauſes, beſides the power of cuſtom, which is confeſſedly very great, conſiſt of an immenſe variety of ſtimuli, that may be divided into *external* and *internal*. The external are calculated to excite the ſlumbering ſenſes, while

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the internal act either immediately on the body itſelf, as the diſtenſion of the urinary bladder; or impreſs the nervous ſyſtem through the medium of the imagination, the mode in which *dreams* operate.

§ 332.

Dreams are light ſportings of the imagination, in which it recalls the images of things formerly perceived, and appears to exerciſe and buſy itſelf in arranging and combining them into the moſt fantaſtical repreſentations.

I have never been able to diſcover the ſlighteſt veſtige of this faculty in new-born infants previouſly to the third month after birth.

There are alſo various examples of adults who explicitly declare, that they have no knowledge of dreams, having never been troubled by them.

Thoſe viſions of the night are, for the moſt part, indeed, confuſed and irregular; but the are, notwithſtanding, ſometimes marked wit aſtoniſhing veſtiges of reaſon.

The influence of ſtimuli acting on the b truly great in the production of dreams: th ſtimulus of the male ſemen gives riſe to luſ

ideas; the ſtimulus of an exceſſive plethora calls up images of a frightful and terrifying nature, &c. We have even received a well confirmed account of a man, to whom, while aſleep, his friends could ſuggeſt whatever viſions they pleaſed, by communicating to him the ſubject and matter of the dream in a ſoft and gentle tone of voice. This appears however, to belong rather to a preternatural ſtate, conſiſting of ſomnolency and wakefulneſs, of which that truly morbid affection of the *ſomnambulantes*, or thoſe who walk in their ſleep, conſtitutes alſo another variety.

It is neceſſary previouſly to the final concluſion of this ſubject to obſerve, that Locke and others have thought proper to conſider all dreams as belonging to this mixed or compound ſtate.

END OF THE FIRST VOLUME.

ELEMENTS

OF

PHYSIOLOGY.

SECTION XXVI.

OF FOOD, AND THE APPETITE FOR IT.

§ 332.

As the waſte of the animal powers is again reſtored by ſleep, ſo in like manner the inceſſant loſs of the natural powers, and even of the very elementary parts of the body, is repaired by freſh and repeated ſupplies of food.

§ 333.

To the acquiſition and uſe of this food we are forcibly led by the frequent and irreſiſtable calls of *nature*. Theſe calls, though widely different from each other in their natures, tend notwithſtanding to the final accompliſhment of the ſame end: they conſiſt, on one hand, of the inſupport-

able torments of *hunger* and *thirſt*; and on the other, of the very pleaſing, but no leſs powerful, allurements of *appetite*.

§ 334.

The ſtimulus of *hunger*, ſome phyſiologiſts have ſought for in the mutual friction between the rugæ of the ſtomach when empty; others in that which appears, indeed, to be of primary importance in giving birth to this potent ſenſation, namely, not only in a more copious ſecretion and afflux of the humours diſcharged into the firſt paſſages, more eſpecially of the ſaliva, the pancreatic juice, and the bile, but alſo in a certain degree of morbid acrimony, with which theſe ſame humours are apt to be contaminated, unleſs ſuch a ſtate be guarded againſt by regular ſupplies of nouriſhment.

§ 335.

Thirſt is a diſtreſſing ſenſation, ariſing principally from a very troubleſome dryneſs of the fauces and eſophagus; and alſo from a peculiar impreſſion produced by taking in acrid, but more eſpecially ſaline, ſubſtances.

§ 336.

With reſpect to the abſolute *neceſſity* of ſatisfying and removing theſe ſtimuli, no fixed and poſitive rule can with propriety be laid down, as ſuch neceſſity

neceſſity is doubtleſs rendered more or leſs urgent by varieties in age, habit of body, and more eſpecially by the power of cuſtom. From a general conſideration of this ſubject, however, the reſult appears to be, that an adult and healthy perſon, who is under no undue impreſſions or influence, (in whom, for inſtance, thoſe aſſuaſive calls of nature are neither ſilenced by the louder ravings of enthuſiaſtic fanaticiſm, nor by other preternatural cauſes) cannot refrain from the uſe of food, for even one whole day, without a very great proſtration of ſtrength; and can ſeldom faſt for more than eight days without incurring the utmoſt hazard of life.

§ 337.

With regard to *drink*, although a deſire for this appears to urge with the greater vehemence and intenſity of the two, it is, notwithſtanding, much leſs neceſſary to life and health than the article of *food*. This we infer, with apparently ſtrict propriety and truth, not only from numerous ſpecies of warm-blooded animals, as mice, quails, &c. that are never impelled by neceſſity to the uſe of drink, but alſo from actual examples of certain individuals of the human race, who have continued, through a long ſeries of time, in the enjoyment of life, health, and ſpirits, without recourſe to the uſe of drinks of any kind.

§ 338.

As to *food*, controverſies have exiſted reſpecting the kind moſt proper to ſatisfy the internal calls of our nature: whether, for example, the ſtructure and conſtitution of the human body correſpond moſt perfectly with food taken from the animal, or with that derived from the vegetable, kingdom; and which of theſe two kinds of ſubſtances nature, therefore, deſigned to conſtitute the aliment of man?

§ 339.

That man is by nature an herbivorous animal, Rouſſeau attempted, with a great degree of acuteneſs, to prove, not only by arguments taken from the figure of his teeth, and the length of his inteſtines, but by the further conſideration, that woman is naturally uniparous, and furniſhed with two mammæ, &c.; to all which might be added, actual examples of rumination having been performed by human ſubjects, a proceſs well known to belong excluſively to herbivorous animals.

Thoſe, on the contrary, who, with Helvetius, conſider man as a carnivorous animal, attempt to ſupport their opinion by the ſhortneſs of his *inteſtinum cæcum*, and other arguments of a ſimilar nature.

§ 340.

§ 340.

But from more accurate obfervation, and a more minute inveftigation of the fubject, it appears, that nature did not intend to reftrict man to the exclufive ufe of either the one or the other of thofe kinds of *aliment*, but more indulgently deftined him to a free participation of both. That this is indeed the kind deftination of man with refpect to the nature of his food, we very naturally infer from his teeth, efpecially the *molares*, and the conformation of his inteftines, briefly mentioned above, poffeffing a middle ftate between the fame parts, as they exift in carnivorous and in herbivorous animals. This prerogative of man is, however, ftill more forcibly demonftrated, by the nature of the articulation which connects the condyles of the lower jaw to the *offa temporum* in human fubjects.

§ 341.

If the obfervations be true (and they furely cannot be doubted) which we ftated on a former occafion, refpecting the high privilege of man, in being by far better calculated than other animals for traverfing an extenfive range of climate on the globe we inhabit, it from thence fpontaneoufly follows, that he would have been indeed very illy accommodated, in being folely reftricted either to the one or the other of the above kinds

 of

of food: for as ſome regions of the globe afford *animal*, and others *vegetable* food alone, the obvious and unhappy reſult of ſuch an excluſive reſtriction would have been, that man, though calculated and deſtined to reſide in all latitudes of the earth, muſt, notwithſtanding, in ſome of them, be denied the uſe of ſuch aliments as nature had rendered eſſentially neceſſary to the continuation of his exiſtence.

§ 342.

Of all animals, with which we are in any meaſure acquainted, man may, with the ſtricteſt propriety and truth, be ſaid to be *omnivorous*. As on the one hand he is calculated to banquet in luxury, amidſt the moſt profuſe variety of delicacies that art can prepare from the immenſe reſources of the animal and vegetable kingdoms, ſo, on the contrary, he is able to retain his health and vigour when ſubſiſting on the moſt ſimple and frugal fare.

Thus, to produce only a very few examples, a great many men even at the preſent day ſubſiſt ſolely on a vegetable diet, ſuch as potatoes, cheſnuts, dates, &c. which conſtituted alſo the food of the firſt progenitors of the human race: for it appears highly probable, that thoſe ſimple and hardy ſons of nature, ſupported life firſt by the fruits and roots

roots of plants, and afterwards, by the more ſubſtantial and durable fare of grains and pulſe.

Some of the Mooriſh tribes in Africa live almoſt entirely on the gum ſenegal.

The inhabitants of Kamſchatka and of a great many other maritime ſituations ſubſiſt on fiſh.

In Europe itſelf, the *Morlachi* are ſupported almoſt entirely on a diet of fleſh.

Some nations of Barbarians ſubſiſt even on raw fleſh, a circumſtance which is undoubtedly true, with reſpect to the Samoids, the Eſquimaux, and certain tribes of people inhabiting South America.

Neither are the liquids made uſe of as drinks, in certain nations, leſs ſingular and ſtriking.

Thus the inhabitants of ſeveral iſlands, which lie between the tropics, more eſpecially thoſe ſituated in the Pacific Ocean, are entirely deſtitute of ſweet and pleaſant water, and therefore, as a ſubſtitute for this fluid, uſe the delicious juice of the *lacteſcent cocoa.*

Others again drink the waters of the briny ocean;—from all which facts and circumſtances,

 taken

taken collectively, together with an infinitude of others that might be adduced, we need not hesitate a moment to pronounce, that man is literally an *omnivorous animal.*

SECT. XXVII.

OF MASTICATION AND DEGLUTITION.

§ 343.

FOR the purpose of masticating the more solid species of food, both our under, and upper jaws, are armed with *three* different kinds of teeth.

These are *first*, the *incisores*, which, in most men, are chisel-formed, and well calculated to bite off morsels of food.

Secondly, the *canini*, strong, conical and completely adapted for breaking substances of greater firmness.

And *lastly*, the *molares*, of different sizes, exquisitely fitted for the process of grinding.

§ 344.

§ 344.

The mandible or lower jaw is connected to the other parts of the head, by means of a very singular variety of articulation, which appears to be of a middle nature between *arthroida* and *ganglimus*. Being furnished with a pair of double concave cartilages, it thus unites, to a sufficient degree of strength and firmness, a capacity of being easily and very considerably moved in all directions.

The under jaw is drawn back, in opening the mouth, chiefly by means of the *musculus biventer*, but in part also by the geniohyoidei and the mylohyoidei.

It is brought back again, when we attempt to cut any thing through with the dentes incisores, and pressed with astonishing force against the opposite jaw, during our efforts to crush any hard substances, by the masseter and temporal muscles.

It is moved laterally in chewing, by the action of the internal and external pterygoid muscles; the latter of which have also the power of moving it in a forward direction.

§ 345.

§ 345.

Subſtances taken into the mouth for the purpoſe of being chewed, are retained, placed in a proper ſituation, and thus effectually ſubjected to the action of the teeth, by means of the *muſculus buccinator*, and the tongue, an organ of extreme flexibility, and very capable of changing its form (§ 233).

§ 346.

During the act of manducation we emulge, as it were, a certain quantity of *ſaliva*, which is an aqueous liquid, of a nature ſomewhat ſaponaceous; it contains a ſmall quantity of earthy matter, (which gives origin to tartarous incruſtations of the teeth, and to ſmall ſublingual calculi); this fluid, from being in perpetual contact with the tongue, makes no ſenſible impreſſions of taſte on that organ, although it contains a ſmall quantity of microcoſmic ſalt; it poſſeſſes antiſeptic and reſolvent properties, and has alſo a power of ſpeedily exciting the proceſs of fermentation in vegetable ſubſtances, eſpecially in thoſe of the farinaceous kind.

§ 347.

The ſources from whence this fluid is derived are, ſmall conglomerate glands, of three ſeveral orders,

orders, the lateral and internal, of which are ſituated beneath the lower jaw.

The moſt conſiderable of theſe glands, called *parotids*, (remarkable, on account of being extremely ſubject to metaſtaſes), excrete their ſaliva through the Stenonian duct, juſt behind the middle molar tooth of the upper jaw.

The ſaliva furniſhed by the *ſubmaxillary* glands, is diſcharged through the duct of Wharton.

That derived from the *ſublingual* glands, which are the leaſt of all, flows through the numerous ducts of Rivinus.

§ 348.

The excretion of ſaliva, (of which, in conformity to the opinion of Nuck, about a pint is commonly ſuppoſed to be ſecreted in the ſpace of twelve hours), is conſiderably encreaſed both by the application of any ſtimulating ſubſtance, and alſo by mechanical preſſure, the latter of which appears to act merely by emulging the containing parts.

Thus, whatever hard ſubſtances we chew, become perfectly moiſtened and macerated, as it were, by a copious afflux of ſaliva produced in

conſe-

confequence of the preffure, to which the *parotids* are particularly expofed from, being fituated fo near to the articulation of the lower jaw.

With regard to the operation of ftimuli on the fecretion of this fluid, it is neceffary farther to obferve, that when acrid fubftances are taken into the mouth, a plentiful afflux of faliva is immediately produced, which has the effect of diluting and thus effectually counteracting the irritating acrimony: an increafe of the fame fluid is alfo occafionally produced by the ftimulus of the imagination; to this caufe muft we refer that afflux of faliva, which fo frequently accompanies a ftrong appetite for food.

§ 349.

With the faliva are blended a fine aqueous, dew-like fluid, which tranfudes from the foft parts of the mouth, and alfo a mucus, fecreted by fmall glands, fituated in the lips and cheeks: it is a portion of this mucus by which the tongue is lubricated.

§ 350.

The morfel during maftication, being thoroughly moiftened by this mixture of faliva and other animal juices, is thus, not only converted by degrees into a foft pulpy bolus, more fit for the purpofe

poſe of deglutition, but is likewiſe prepared, at the ſame time, for further digeſtion and final aſſimilation.

§ 351.

The actual buſineſs of deglutition, although it appears to be of a very compound nature, and is indeed performed by the co-operation of a great many different parts, may be conſidered as commencing and proceeding in the following order; viz. the tongue being firſt retracted towards its baſis, and becoming therefore ſomewhat turgid and ſtiff, receives on its excavated *dorſum* or back, the lubricated and moiſtened bolus, which is from thence forced onwards into the fauces, where it is received by the expanded *infundibulum* of the *pharynx*, which appears, at the ſame time, to advance ſomewhat upwards; on the reception of the food the infundibulum makes a ſingular and violent exertion, which may be ſuppoſed to proceed from a ſpecies of *vita propria;* from this funnel-like entrance, the bolus is again protruded onward, by a threefold contraction of the pharynx, into the *œſophagus*. All the above motions ſucceed each other with the utmoſt degree of rapidity, and are of extremely ſhort continuance.

§ 352.

For the purpoſes of expanding this paſſage, and rendering it at the ſame time ſteady and ſecure, nature

nature has made the moſt ample proviſion by a variety of auxiliary parts.

The motion of the tongue, in this momentous buſineſs, is regulated and directed by the os hyoideum.

To prevent any of the ſubſtances ſwallowed, from paſſing, by miſtake, either into the internal nares, or into the euſtachean tubes, the ſoft palate is very wiſely provided. This fleſhy curtain, depending equally from the arched roof to which it is attached, is capable of being rendered tenſe by the action of a peculiar ſet of muſcles, and thus the above paſſages may be completely cloſed.

The *glottis* is ſecurely guarded by the tongue itſelf, becauſe at the very inſtant in which we attempt to ſwallow, the larynx, being drawn upward and forward, is in a certain degree concealed beneath the retracted baſis of the tongue, and is ſo compreſſed by it, that the glottis, not only by this conſtriction, but alſo by the additional ſecurity of the epiglottis, is thus very effectually guarded againſt the intruſive entrance of any heterogeneous ſubſtances.

§ 353.

Finally, the buſineſs of deglutition is greatly facilitated by means of a quantity of mucus, with which

which the whole of the paſſage above deſcribed is lubricated; and which, beſides the lingual glands already mentioned (§ 235), is chiefly furniſhed by the numerous ſinuſes of the tonſils, and by that infinitude of mucaginous *cryptæ*, ſo profuſely beſtowed on the larynx itſelf.

§ 354.

With reſpect to the *œſophagus* itſelf, through which all ſubſtances ſwallowed muſt neceſſarily paſs, previouſly to their entrance into the ſtomach, it is a fleſhy canal, rather narrow in its diameter, and exceedingly firm and ſtrong, but at the ſame time pliable, dilatable, and poſſeſſed of a high degree of ſenſibility: it is compoſed of tunics or coats, which, if we except the difference in their thickneſs, bear no ſmall reſemblance to the coats of the other portions of the alimentary canal.

Thus, the external covering is muſcular, made up of fibres running both longitudinally and in tranſverſe or circular directions.

The middle coat is nervous, ending on each ſide in a very lax cellular membrane, by means of which it is connected, as well to the preceding, as to the ſubſequent tunic.

Laſtly,

Laſtly, the internal coat is lined by mucus of an exquiſite degree of lubricity.

§ 355.

The following appears to be the mode in which this canal performs its office; as ſoon as it has received either a draught or bolus completely within its *parietes*, the parts immediately above preſently contract themſelves, thus forcing downwards the ſubſtance to be ſwallowed; which, if it be a bolus, can be protruded onward only by one uniform ſeries of exertions in the ſurrounding tube, till it has paſſed through the diaphragm, and been finally received into the cavity of the ſtomach itſelf.

SECT. XXVIII.

OF DIGESTION.

§ 356.

THE chamber, or immediate ſeat of digeſtion, is the *ſtomach*, a viſcus more uniformly poſſeſſed than any other, by almoſt every individual throughout the immenſe range of *animated nature*: if, therefore, we eſtimate the dignity of the ſeveral viſcera from this circumſtance alone, the ſtomach is, doubtleſs, to be conſidered as an

I organ

organ furpaffing all the others in utility and importance to the animal economy.

§ 357.

The human ftomach refembles a leathern pouch, of very confiderable dimenfions, fufficient, for the moft part, in an adult, to contain three pints, or more, of water, and furnifhed with two feparate orifices or mouths :

Thefe are, *firft*, a fuperior orifice, called *cardia*, which is formed in the place where the œfophagus, by a plaited and fomewhat oblique aperture, opens into the ftomach itfelf, and points towards the bottom of this vifcus, or that extremity which regards the left fide of the body.

Secondly, an *inferior* one, which conftitutes the termination of the right, and lefs capacious end of the ftomach : this orifice is called *pylorus*, and defcends a fhort diftance into the cavity of the adjoining duodenum.

§ 358.

The fituation of the ftomach, when empty, is different from that of the fame organ, when full : thus, in the *former* ftate, it hangs loofe and flaccid in the abdominal cavity, in fuch a manner that its greater curvature looks in a backward direction ;

and its pylorus, being turned ſomewhat upwards, forms a plaited or twiſted angle with the duodenum, to which it is connected.

But in the *latter* ſtate, when diſtended with food, its greater curvature is again turned, and looks in an anterior direction, ſo that the pylorus enters now, by a more direct route, into the duodenum; whereas the cardia, on the contrary, is ſo folded and bent as to be completely cloſed.

§ 359.

The ſtomach is compoſed of four principal coats, diſtinguiſhed and ſeparated by three others, of an entirely cellular nature, which lie between them.

The moſt *external* of theſe coverings is common to the ſtomach, with all the reſt (ſave a ſmall portion) of the alimentary canal, and is continued over the *omenta*, which ſhall be ſpoken of hereafter.

Next to this, lies that *cellulo-muſcular* coat, ſo very ſtriking in its nature and properties, on which depend both the exquiſite *irritability* of the ſtomach (§ 306.), and alſo its periſtaltic motion; the latter of which ſhall be a ſubject of conſideration in another place. This coat is compoſed of dif-

ferent

ferent ſtrata of muſcular fibres, which are uſually divided into three orders, one longitudinal, and two circular; the circular fibres are again divided into thoſe that are *directly*, and thoſe that are *obliquely*, circular. It muſt, however, be obſerved, that ſo extremely variable and irregular are the fibres of this coat, with regard to their direction and diſtribution, as ſcarcely to admit of reduction to, and arrangement under, any determinate and general rules.

The third principal coat is called the *nervous*, an appellation extremely improper, as it is compoſed wholly of condenſed cellular membrane, becoming gradually more ſoft and lax on each ſide; by which means it is connected externally to the muſcular, and internally to what we ſhall preſently call the *villous*, coat. It is, notwithſtanding, ſo firm and robuſt, that it may be aptly enough called the *baſis* of the whole ſtomach.

Laſtly, the *internal* coat, which has been very improperly called *villous*, is exceedingly tender, ſomewhat ſpongy, porous, and folded into a very great number of rugæ or wrinkles, ſo that its area is much more extenſive than that of any of the other coats which we have juſt deſcribed: it every where exhibits cells of the utmoſt minuteneſs, ſome-

what ſimilar in appearance to thoſe larger ones, with which the *reticulum* of ruminating animals is very beautifully and elegantly characterized.

The internal ſurface of this coat is lined with mucus, apparently ſecreted by ſmall mucaginous cryptæ, ſome of which may be, indeed, readily enough diſtinguiſhed near to the *pylorus*, or lower orifice of this organ.

§ 360.

The ſtomach is furniſhed with an aſtoniſhing apparatus of nerves, whence its ſenſibility is ſo exquiſite, that it is capable of being very readily affected by ſtimuli of almoſt every kind, whether they be *external*, as cold &c. or *internal* as food, and even by the inquiline humours themſelves. From the ſame ſource ariſes alſo that extenſive, and truly admirable conſent, which exiſts between this important viſcus and moſt of the other functions of the body; to which head belongs, in a particular manner, the ſtriking effects, produced on the ſtomach, by all mental commotions, and alſo, on the other hand, the very powerful influence of an entirely ſound and healthy ſtate of this organ, on the cheerfulneſs and ſerenity of the *mind.*

§ 561.

§ 561.

The number and functions of the *blood vessels*, belonging to the ſtomach, are no leſs conſiderable and ſtriking, than thoſe of the *nerves*. The ſmall arteries, (of which an infinitude of different orders, are minutely interſperſed throughout the cellular coats of this organ), appear to conſtitute the immediate ſources of the *gaſtric juice*, a liquor which flows in perpetual ſtreamlets from the internal ſurface of the ſtomach.

§ 362.

This juice bears, on the whole, no ſmall reſemblance to ſaliva, except that, agreeably to the experiments of the illuſtrious Spalanzani, its *powers* are counter to *thoſe* which promote fermentation. As to the reſt of its properties, it is ſaponaceous, equally antiſeptic with the ſaliva, and is indeed, a very powerful menſtruum, ſufficient gradually to diſſolve milk after it has been gently coagulated in the ſtomach.

§ 363.

The gaſtric juice appears to be the moſt powerful and active agent in the great buſineſs of digeſtion. If the *food* be carefully maſticated, and ſufficiently blended with the menſtruum furniſhed by the ſalivary glands, this fluid of the ſtomach com-

pletely diffolves, and finally converts it, into a foft pultaceous chyme.

§ 364.

This momentous function is alfo further aided and promoted, by a variety of acceffory and affiftant powers: of thefe the moft confiderable is the *periftaltic motion*, by means of which the food, now reduced to a pulpy confiftence, is thoroughly agitated, and kept perpetually in a ftate of wavy commotion. Although the force of the periftaltic motion fall far fhort of the chimerical calculations, formerly made on this fubject, by mathematical phyficians, and although it be not itfelf the fole caufe of digeftion, it is, notwithftanding, of the utmoft efficacy and influence in this important procefs.

§ 365.

Among the auxiliary powers, of this kind, may be alfo reckoned another fpecies of motion, which the preffure of the furrounding parietes of the abdomen, communicates to the ftomach: to thefe we may ftill farther fubjoin, the extreme warmth of the fituation in which this vifcus is placed; fo very powerful was this *fotus* or bath, formerly efteemed, in confequence of the abundant quantity of blood contained in the neighbouring veffels

and

and viſcera, that inſtead of the term *digeſtion*, that of *coction*, was uſed by the greater part of phyſiologiſts.

§ 366.

To determine, with preciſion, the period of time requiſite for the *converſion* of our aliment into chyme by the joint co-operation of the foregoing powers (§ 361.), will appear almoſt impoſſible to any one, who may conſider the great variety of circumſtances, on which ſuch converſion muſt depend: theſe circumſtances are, the quality and quantity of the food taken in, the different degrees of force in the digeſtive powers, the greater or leſs attention and care beſtowed on the preparation of the food for digeſtion, by previous maſtication, &c.

For in a healthy ſubject, the unimpaired ſtomach does not diſcharge ſuch alimentary matters as have been taken in, previouſly to the converſion of their digeſtible parts into a perfect pulp. From whence it is evident, that different periods of time are requiſite, for the complete digeſtion of different kinds of food. If, however, it be allowable to form any general concluſion on this ſubject, it would appear, that from the third, to the ſixth hour, after the uſe of aliment, the ſtomach has, for the moſt part, diſcharged through the pylorus,

in a very gradual manner, the whole of its pultaceous contents.

§ 367.

The pylorus is an annular rim, not formed, (like the other rugæ on the internal ſurface of the ſtomach), by the folding of the villous coat alone, but conſiſting, in part, alſo of a few *faſciculi* from the ſubjacent *nervous*, and alſo of certain fibres from the *muſcular*, coat: all which parts are ſo organized and arranged, as to conſtitute a coniform termination to the ſtomach, that is extended into, and embraced by, the duodenum, in the ſame manner as the *os uteri* is received and embraced, by the ſuperior part of the vagina.

SECT. XXIX.

OF THE PANCREATIC JUICE.

§ 368.

SUBSEQUENT to the expulſion of the chyme through the pylorus, that pulpy maſs muſt be ſubjected, in the duodenum (a ſhort, but remarkable portion of the inteſtinal tube), to new and conſiderable changes, previouſly to the formation

mation and final ſeparation of complete, alimentary chyle. Theſe neceſſary changes are effected in the chyme by the acceſſion and admixture of various kinds of inquiline humours, the moſt ſtriking and important of which, are, the *bile* and the *pancreatic juice*.

§ 369.

Of theſe two humours, we will ſpeak in ſeparate ſections. We proceed therefore, to conſider the liquor of the pancreas firſt, becauſe it appears to bear a very conſiderable reſemblance, both in its nature and uſes, to thoſe other two diſſolvent humours, of which we have already ſpoken, namely, the ſaliva and the gaſtric fluid.

§ 370.

Athough it be indeed a matter of no ſmall difficulty, to procure the pancreatic liquor of a ſound animal, in a pure and unadulterated ſtate, yet the obvious and unequivocal reſult of all the facts, which the moſt attentive inveſtigation has been able to ſupply, with regard to its nature, is, that it bears the ſtrongeſt ſimilitude to the ſaliva in all its general properties. Were it not for the purpoſe of ſhowing how miſchievous, and even deſtructive, the practice of medicine may become, unleſs directed by ſound principles of phr[illegible]ology, I ſhould not think it neceſſary nor ev[illegible]oper, at the

the prefent enlightened period, to mention the erroneous phyfiological hypothefes, entertained by Franc. Sylvius, and his humble followers, Regn. de Graef, Flor. Schuyl, and others, refpecting the vifionary or fuppofed acidity of the pancreatic liquor, efpecially as thofe opinions have been long fince very ably refuted by *Pechlin*, Swammerdam, and Brunner, characters of the firft celebrity in the annals of medical fcience.

§ 371.

The fources from whence the lymph and faliva are derived, bear no fmall refemblance to that which conftitutes the fubject of our prefent confideration, namely, the *pancreas:* this latter is by far the largeft of all the conglomerate glands of the human body, and exhibits, in the whole of its ftructure, a very ftriking fimilitude to the glands, that give birth to the falivary fluid; with thefe laft mentioned bodies it alfo further agrees, in this particular, that its excretory canals, arifing from radicles of the utmoft minutenefs, run together and unite by degrees, till they conftitute finally a common duct, which has received its name from Jo. G. Wirfung, who firft difcovered and demonftrated it in the human fubject, in the year 1642.

This

This duct passes through the coats of the duodenum, and by a constant *stillicidium*, weeps into the cavity of that intestine, the fluid it had received from the gland to which it is appended.

§ 372.

Finally, the excretion of this fluid appears to be promoted by the very same powers, which were formerly said to be subservient to the excretion of saliva, namely, *pressure* and *stimulus*.

By means of the former, it is emulged chiefly when the stomach is distended and rests immediately on the pancreas.

The substances that contribute most, by their irritations, to excite a discharge of the pancreatic fluid are, first, the chyme itself, as it passes through the pylorus in a crude and unassimilated state; and secondly, the bile, which is discharged through the very same orifice with the liquor of the pancreas.

§ 373.

The use of this fluid is doubtless to dissolve the chyme, more especially that part of it, which has not been sufficiently digested in the stomach: by its abundant afflux, it contributes to assimilate this pulpy

pulpy maſs ſtill more and more to the nature of the inquiline humours, and thus finally mature it for the further proceſs of chylification.

SECT. XXX.

OF THE BILE*.

§ 374.

THE ſecretion of bile is the peculiar deſtination of the *liver*, the largeſt and moſt ponderous viſcus in man. This ſuperiority of ſize is more eſpecially obſervable, during the fœtal

* Doctor Maclurg, of Virginia, publiſhed in the year 1772, an experimental treatiſe on the formation, the nature and the uſes of the human bile, which has acquired for its learned and ingenious author, no ſmall degree of reputation both at home and abroad. That this elaborate publication poſſeſſes an uncommon ſhare of merit, not even the avowed enemies of the Doctor are themſelves able to deny. The author has ſhewn himſelf to be, at leaſt, a very patient experimenter, and an extremely attentive obſerver. He appears to have made himſelf perfectly maſter of the opinions of all authors of celebrity and diſtinction, who had previouſly written on the ſame ſubject. With regard to the literary merit of the compoſition itſelf, it is doubtleſs entitled to the higheſt encomiums that even the moſt partial eulogiſt can beſtow. The order

ſtate, in which, the younger the fœtus the greater is the proportional magnitude of the liver, when compared with that of the other viſcera of the

order is inimitably lucid, the ſtyle is chaſte, manly and nervous in the higheſt degree, and as to cloſeneſs and propriety of argumentative arrangement, not even the ſupercilious logician himſelf, can find room to ſuggeſt the ſhadow of an amendment.

All human compoſitions are, however, like the ſources from whence they originate, in ſome meaſure faulty and imperfect. To this general maxim, humiliating as it may appear to the pride of the ſelf-adoring philoſopher, the treatiſe of the illuſtrious Maclurg is by no means an exception. In ſeveral of the Doctor's experiments there appears to be a want of ſufficient accuracy and definitude, in others a want of object and deſign. Over theſe faults, however, conſiderable as they are in the works of an experimentaliſt, we feel inclined to ſpread a kind mantle of palliation, when we recollect that our author experimented and wrote in the early morn of ſcientific chemiſtry. Experimenters had not yet become perfect adepts in their nice and momentous art; they had not yet acquired ſufficient circumſpection and addreſs to obviate every ſource of fallacy, and to avail themſelves of every circumſtance that might pave the way to ſatisfactory and unequivocal reſults.

But another charge of a more weighty and important nature, lies againſt our learned and ingenious author. He has certainly built, on nothing more ſubſtantial than the flimſy baſis of deceptious analogy, ſome of the leading principles of his favourite doctrine. Thus, for example, he ſuppoſes the bile

body. The dignity and high importance of this viſcus in the animal economy may be fairly deduced, from the univerſality of its preſence; thus

bile to be a fluid, the direct reſult of a putrefactive degeneracy in a portion of the circulating volume of the blood. His moſt plauſible reaſons in ſupport of this opinion are, *firſt*, that the parts, from whence the incipient radicles of the vena portarum immediately originate, contain, and communicate with, matter already in a ſemiputreſcent ſtate. And *ſecondly*, that the bile is moſt abundant in quantity and moſt active with regard to its quality, at that ſeaſon, and under thoſe circumſtances, which are moſt favourable to the commencement and progreſs of putrefaction in the living ſyſtem, as well as in all other phyſical bodies.

Plauſible as thoſe arguments may, on firſt view appear, they are certainly, as already obſerved, founded on nothing better than fair, but fallacious analogy. The principle which they tend to eſtabliſh ſtands in the moſt direct oppoſition to the reſult of experiment—ſacred experiment! the only unerring guide to conduct the candid enquirer to the everlaſting temple of truth. Did our learned author (I would beg leave to aſk) ever faithfully experiment on ſeparate portions of the blood, drawn from different parts of the body, in order to determine the comparative proximity of each portion, to the putrefactive ſtate? I preſume he never did, otherwiſe his opinion on this ſubject would have been, doubtleſs, very different from what we find in his ingenious publication. For it is a truth, nothing the leſs ſacred and reſpectable on account of its novelty, that if equal quantities of blood be taken from the *vena portarum*, and from the lungs or any part of the arterial ſyſtem, and expoſed to the ſame incumbent circum-

in all animals poffeffing red blood, it exifts no lefs generally and uniformly than the heart itfelf.

circumftances, the *pulmonic* or *arterial*, will affume the putrefactive procefs, much fooner than the *hepatic*, blood. The caufe of this phenomenon muft be fufficiently obvious to any one acquainted with the late difcoveries, in the divine fcience of chemiftry. We would attempt its folution in the following manner.

Vital air (which is indeed the genuine feptic principle, if any fuch principle exift) is in all cafes effential to the progrefs of putrefaction. This air, or rather its bafe (termed oxygene by the ingenious chemifts of France) is, as we have the ftrongeft reafons to believe, from the experiments of Goodwyn, Beddoes, Girtanner, and others, intimately blended with the circulating blood in its paffage through the lungs. As the blood proceeds in its mazy route through the different parts of the arterial fyftem, it is gradually robbed of its concommitant oxygene or bafe of vital air, by the myfterious action of the animal fyftem. The confequence of this fpoliation is, that the florid *arterial*, affumes a much darker colour, and fuffers finally a complete tranfmutation into *venous* blood. In this latter ftate the putrefactive procefs is lefs apt to commence, becaufe the blood contains lefs oxygene in a ftate of intimate mixture, or perhaps I might with more propriety fay, in a ftate of combination. For in proportion as the bafe of vital air is more intimately blended with, and therefore more nearly approximated to, the conftituent parts of the blood, the more powerfully can it co-operate with other auxiliary agents, in inducing *thefe parts* to affume that inteftine motion, which conftitutes the putrefactive procefs. Although our learned author is decidedly of opinion, that putrefaction commences more readily, if vital air be excluded altogether from

§ 375.

The ſubſtance of the liver is of a nature, *ſui generis*, and may be readily diſtinguiſhed, at firſt

from the putrefying ſubſtances, yet it is now well known, that the very reverſe of this is true. Exclude vital air from a body, in the compoſition of which none of this energetic fluid exiſts, and you thereby embalm that body in a degree equal, if not ſuperior to the embalmment of the unperiſhable mummies of the Eaſt.

No body, whatever, is capable of taking on the putrefactive proceſs, that does not contain in its compoſition more or leſs of thoſe ſimple ſubſtances that belong to the claſs of *inflammables*. Reaſoning therefore a *priori*, or climbing the arduous ſteeps of ſcience by the more laborious ſteps of experiment and obſervation, we are warranted in either caſe to conclude, that putrefaction conſiſts, in a very conſiderable degree, in the intimate combination of the baſe of vital air to certain ſubſtances of an inflammable nature. Both the primary elements of which putrefiable bodies are compoſed, and alſo the reſults of actual putrefaction, co-operate in the eſtabliſhment of the ſame concluſion.

It is certainly a truth, that vital air is as eſſential to the putrefactive proceſs as it is to the ſupport of combuſtion, or the continuance of animal life.

Upon the whole, we may without the ſmalleſt heſitation conclude, that the former opinions of phyſiologiſts reſpecting the ſuppoſed putreſcent diſpoſition of the hepatic blood, are wholly inſupportable by argument or fact, being indeed directly oppoſed to the literal reſult of poſitive experiment;

 and

ſight, from that of all the other viſcera of the body: it conſiſts of a parenchyma of a well known colour and very tender texture: this parenchyma is abundantly ſupplied with nerves, with lymphatic veſſels (very viſible on both ſurfaces), with biliferous ducts, and finally with blood-veſſels, from whence theſe ducts originate: with reſpect to theſe blood-veſſels, ſome of which are remarkably large, we will immediately ſtate a few obſervations on each of their ſeveral orders.

§ 376.

The firſt veſſel which here preſents itſelf for our conſideration is, the *vena portarum*, which differs very widely from every other portion of the venous ſyſtem, not only in its ſingular appearance, but alſo in the peculiarity of its courſe and diſtribution, of which a few words were ſpoken on a former occaſion (§ 87). This large veſſel is formed by the conflux of by far the greater number of the venous branches that originate and run from the viſcera, ſituated in the lower part of the abdomen, and is inveſted and ſtrengthened by

and therefore, that the pious eulogia ſo profuſely beſtowed on the powers of the animal economy, in being able to form an *antiſeptic* out of a highly *putreſcent* fluid, appear to be as viſionary and hypothetical, as *nature's* final intention in the preparation of this fluid was thought to be beneficent, and her proceſs itſelf beautiful, and intereſting.

a cellular covering, commonly known by the name of *capſula Gliſſonii.* No ſooner does this trunk make its entrance into the liver, than it is divided into ſeveral branches, which as they run in various directions through its ſubſtance, ſuffer ſtill farther diviſions, till they are finally encreaſed to a countleſs number of the moſt ſubtle ramifications, which pervade, with the utmoſt minuteneſs, every portion of this viſcus. This whole ſyſtem of the vena portarum was formerly compared, by Galen, to a tree, the roots of which are diſperſed throughout the whole cavity of the abdomen, while its branches are encloſed in the more contracted volume of the liver.

§ 377.

Another blood-veſſel of a different kind, with which the liver is furniſhed, is the *arteria hepatica.* This veſſel originates from the cæliac artery, and although far inferior to the vena portarum, both in its capacity and in the number of its branches, is, notwithſtanding, divided into ramifications of aſtoniſhing ſubtility, and is alſo diſtributed with a great deal of minuteneſs throughout every part of the liver.

§ 378.

The extreme terminations of both the foregoing kinds of veſſels, end in genuine veins, which gradually

gradually uniting, form by their general conflux, certain large venous trunks, that loſe themſelves finally in the inferior *vena cava*.

§ 379.

Thoſe extreme terminations, by which theſe ſmall branches of the vena portarum and arteria hepatica become radicles to the vena cava, form a very ſubtle vaſcular texture, exhibiting a ſingular and ſtriking appearance, as if the veſſels were convoluted, or wound up into globes of inconceivable minuteneſs. Theſe globular bodies impoſed ſo effectually on Malpighi, as to induce that illuſtrious phyſiologiſt to conſider them as glandular, hexagonal, and hollow kernels, deſtined to conſtitute the immediate chambers of ſecretion.

§ 380.

From thoſe ſame globular convolutions of blood-veſſels ariſe, laſtly, the *pori biliarii*. Theſe are very tender ducts, which convey the galliſh liquid from the blood, and completely eliminate the ſame from the ſyſtem of the liver, through the *ductus hepaticus communis*, a canal which they form by their general conflux.

§ 381.

It is common for phyſiologiſts to enquire, from what kind of blood the bile is immediately

 ſecreted;

ſecreted; whether from arterial, or from that contained in the *vena portarum?*

Although the former of theſe opinions appears, on the firſt view of the ſubject, to be rendered moſt probable from the analogy of other ſecretions, which are evidently the reſult of arterial action, yet from a more accurate inveſtigation of the matter we will readily be convinced, that by far the greater part, if not indeed the whole, of the biliary ſecretion, is derived from the vena portarum: the blood of this veſſel being lurid, and highly impregnated with phlogiſton, correſponds preciſely with the nature of the bile; but how extremely different, on the other hand, are the habit and conſtitution of the florid and fiery arterial blood, which the cæliac artery tranſmits from the aorta immediately to the liver!

With reſpect to arguments drawn from analogy we may obſerve, that as the vena portarum is ſubjected to an arterial diſtribution, ſo it may, in like manner, poſſeſs the power of performing an arterial function: this ſame opinion, for which we contend, appears alſo to derive additional ſupport from the analogy which exiſts between the liver and the lungs: to perform the leading function of theſe laſt mentioned viſcera, is doubtleſs the immediate deſtination of the large pulmonary arteries; whereas,

whereas, on the other hand, the bronchial artery is only fubfervient to the nourifhment of the parts, on which it is diftributed :—the difcharge of an office, fimilar to this latter, is alfo, if we be not greatly deceived, the more immediate deftination of the *arteria hepatica*. Notwithftanding what we have here advanced, we are ftill ready to acknowledge, that the hepatic artery may poffibly contribute fomewhat towards the fecretion of bile; but, that its influence, in this refpect, is indeed very inconfiderable, and not yet fufficiently afcertained and demonftrated, are pofitions to which we fubfcribe with the utmoft confidence.

382.

The biliary *hepatic liquor*, when once fecreted, flows in a gentle but uninterrupted ftreamlet through the *hepatic duct*; and, when the *inteftinum duodenum* is empty, glides directly onward, through the common *ductus choledocus*, into the cavity of that vifcus; but when the duodenum is diftended with chyme, it becomes neceffary for this fluid to purfue a different route, whence it regurgitates from the *hepatic*, and flows through the *cyftic duct* into the gall-bladder, where it is retained a certain time, and thence derives the name of *cyftic bile*.

§ 383.

The *gall-bladder* is an oblong ſack, ſomewhat pyriform in its figure, attached to the concave ſuperficies of the liver, and compoſed of three membranes or coats.

Theſe are, firſt, the *external*, which does not inveſt the whole of the cyſt, and is derived from the peritoneum.

Secondly, the *middle*, uſually called the nervous coat, which, as in the ſtomach, the inteſtinal tube and the urinary bladder, conſtitutes here likewiſe the principal part of the tone and firmneſs of the ſac.

And, laſtly, the *internal*, which bears a certain ſimilitude to the internal membrane of the ſtomach (§ 359.); like that it is interſperſed with an infinitude of minute blood-veſſels, and like that it is alſo marked by rugæ or wrinkles, which form, here and there, fine net-like checkerings, that exhibit the appearance of the moſt exquiſitely elegant lattice-work.

§ 384.

The neck of the gall-bladder is conical, and forms, by its termination, the *cyſtic duct*, which purſues

pursues not a direct, but somewhat circuitous or serpentine route, and is furnished with a few minute valves of a lunated or falciform figure.

§ 385.

The gall-bladder retains the bile, when once received, till that liquor either flows out spontaneously, in consequence of being favoured by a reclined and somewhat supine position of the body, or till it is emulged from the cyst by the pressure of the neighbouring intestines, namely, the *jejunum* and *ileum*, or by the occasional passage of hardened fæces through the transverse colon.

Different stimuli acting on the duodenum have also the effect of soliciting a more copious effusion of bile into the cavity of that intestine.

The remarkable *contractility* of the gall-bladder, evidenced and satisfactorily established by live dissections and certain pathological phenomena, (although this sac be indeed completely destitute of all genuine *irratibility)*, (§ 307.), will appear to contribute, not a little, to the excretion of the bile; especially when we consider the stimulant impression which this fluid, after retention in the cyst, must make on its surrounding *parietes* or walls.

§ 386.

For although the *cyſtic* exhibits, in its general properties, the moſt ſtriking ſimilitude to the *hepatic* bile (§ 382.), it is notwithſtanding concentrated, as it were, by reſt and ſtagnation, and thence rendered more tenacious and bitter: this effect appears to be owing, in a particular manner, to the lymphatic veſſels of the cyſt, which ſlowly abſorb the aqueous parts of the bile, while thus encloſed and retained in a quieſcent ſtate.

§ 387.

We proceed now to the conſideration of the bile itſelf. This is an animal fluid of the higheſt dignity and importance in the living ſyſtem; its nature and uſes have, for twenty pears paſt, laid a foundation for more literary controverſies among phyſiologiſts, than have exiſted reſpecting any other fluid that belongs to the body of man.

What we ſhall advance on this ſubject will relate immediately to the cyſtic bile, as this is to be eſteemed the more perfect of the two, and is therefore in a ſtate more favourable for ſucceſsful inveſtigation.

§ 388.

Bile, taken from the recent corpſe of an adult ſubject, who had not previouſly laboured under any

any diſeaſe, is a liquor ſomewhat viſcid, of a faint green colour, inclining towards a brown, inodorous, and, if compared with the gall of brutes, of a ſlightly bitteriſh taſte.

§ 389.

Although the conſtituent parts of this fluid neither ſeparate from each other ſpontaneouſly, nor yet by ſo ſimple a mode of treatment as is ſufficient to produce that effect on the parts that compoſe the blood, they may, notwithſtanding, be ſubjected, without much difficulty, to ſuch an examination as will make it appear, that they doubtleſs poſſeſs and exhibit a certain analogy to the elementary parts of the blood, though this analogy ſhould not be purſued to too great an extent.

The bile contains, in the firſt place, an aqueous menſtruum, which has been denominated by ſome late phyſiologiſts, its *ſalivary* part: this may be aptly enough compared to the aqueous portion, and reſembles alſo, though not in every particular, the ſerum of the blood.

From the bile we can alſo ſeparate and procure a ſmall portion of a white and grumous ſubſtance, which may be ſaid to poſſeſs a certain, though remote reſemblance to the plaſtic *lymph* of the blood.

Finally,

Finally, the moſt ſtriking and important principle which the bile contains is the *matter* of *phlogiſton*, derived in large quantities from the blood of the vena portarum, which is highly impregnated with this ſubtle element.

§ 390.

This active inflammable part evidently manifeſts its exiſtence in dried bile, but more eſpecially in gall ſtones, by burſting immediately into flame, when placed in contact with a burning ſubſtance. To the action and influence of this principle muſt we attribute thoſe ſtriking and ſingular qualities, formerly enumerated, ſuch as colour, taſte, &c. which ſerve to diſtinguiſh the bile from the other inquiline humours belonging to the ſyſtem; and from the ſame ſource muſt we alſo derive the other remarkable properties of this fluid, which ſhall be mentioned hereafter.

§ 391.

The bile is not of ſuch a nature as to poſſeſs, like ſoap, an equal affinity to oil and water, and thus ſerve to mix and intimately combine theſe two elements together. The contrary opinion (which was erroneouſly entertained on this ſubject by Boerhaave, and afterwards by Schroder) was formerly invalidated and refuted by certain remarkable experiments of my own (ſince confirmed and

and further increafed by other writers), and is now entirely repudiated by the greater number of phyfiologifts. On the other hand, if bile be applied to the two foregoing elements, i. e. oil and water, when in a ftate of intimate mixture and combination, it produces an evident difunion and feparation of them from each other. This fluid poffeffes indeed no alkaline properties, but is, notwithftanding, equally unfriendly to the exiftence of acid acrimony, to fermentation, and to putrefaction.

§ 392.

By confidering with due attention the foregoing obfervations, we may eafily afcertain the true, the important, and the diverfified ufes of the bile, in the procefs of chylification.

For in the firft place, from that equable and uniform chymous pulp which the ftomach has difcharged into the duodenum, which the pancreas has diluted by an effufion of its own juice, and which moves fpontaneoufly onward to the cavity of the fmall inteftines, it gradually precipitates the fæces, and thus feparates from them that creamlike fluid denominated *chyle*.

The

The bile itſelf ſuffers, at the ſame time, a diviſion into two parts, the one aqueous, the other phlogiſtic. The latter part adheres to the fæces, tinges them, and is afterwards diſcharged, along with them, out of the body; whereas the former appears to be mixed with the chyle, and re-conducted back to the maſs of blood.

Thus the abundant phlogiſton, now become troubleſome and noxious to the blood, is firſt directed to the liver, where it is rendered ſubſervient to the formation of a ſingular and very important humour: After this humour has fully anſwered the end of its deſtination, its ſuperfluous, or rather noxious part is included among the excrements, and finally eliminated from the ſyſtem.

A further uſe of the bile is, to evolve and exterminate from the alimentary canal, the fixed air, which had been hitherto confined among the chymous maſs: it appears alſo to act on, and aid, the inteſtinal tube, by means of its ſtimulus, thus exciting it to perform its periſtaltic motion with greater vigour and energy.

I ſilently pretermit a variety of other uſes, commonly attributed to the bile, which appear to me to reſt on more doubtful and equivocal evidence, ſuch,

ſuch, for inſtance, as its power of regurgitating into the ſtomach when empty, and thus exciting appetite, a phenomenon that, in my opinion, can very ſeldom occur in a well formed and healthy human ſubject.

SECT. XXXI.

OF THE FUNCTION OF THE SPLEEN.

§ 393.

THE *ſpleen* is very intimately connected with the liver, not only by an intercourſe of veſſels, but alſo by the affinity and ſubſerviency of its function: it is ſituated in the left hypochondriac region, oppoſite to the liver; its figure is oblong, generally, indeed, accommodated to the ſituation of the neighbouring viſcera with which it lies in contact: it is ſubject however, to multiplex varieties with regard to form, number, and other ſpecies of *luſi naturæ*, or preternatural phenomena.

§ 394.

Its colour is livid, its texture altogether ſingular, being ſoft, friable, eaſily lacerated, and therefore

fore fecurely protected by two membranous coverings, the internal of which belongs properly to the fpleen itfelf, while the external appears to be derived from the omentum.

§ 395.

The fituation and fize of the fpleen are now and then, no lefs than its figure, fubject to ftriking and fingular variations, arifing in a great meafure from the different ftates of the ftomach, with refpect to fulnefs and depletion: thus, for example, when the ftomach is empty, and hangs in a loofe and depending pofition, the fpleen is diftended with blood; but when the former vifcus becomes turgid again, the latter is emulged, and confequently diminifhed in bulk by the preffure to which it is fubjected.

The fpleen is alfo agitated by another perpetual, though gentle and uniform motion, in confequence of refpiration, being fubjected to the immediate action of a primary inftrument of that function, namely, the diaphragm.

§ 396.

The texture of the fpleen, phyfiologifts formerly fuppofed to be cellular, and uniformly compared it to the *corpora cavernofa* of the penis: this opinion, however, is evidently founded in error, and has

has been very ſatisfactorily refuted by a more accurate examination of the human ſpleen. For, from ſuch examination we learn, that almoſt the whole volume of this viſcus is compoſed of blood veſſels, extremely large in proportion to its ſize; ſo that it is ſupplied with a greater profuſion of blood, than any other part belonging to the body of man.

§ 397.

The ſplenic artery, conſpicuous (agreeably to the experiments of Wintringham) on account of the aſtoniſhing fineneſs and ſtrength of its coats, is divided into an infinitude of minute ramifications, which conſtitute finally, by their evaneſcent extremities, very ſmall pulpy pencils: theſe pencils afford origin, again, to fine filiform veins, that conſtitute by their gradual confluence, large and lax trunks highly capable of dilatation.

§ 398.

This vaſt congeries of blood veſſels, is, however, knit together and ſupported by a ſmall quantity of cellular parenchyma, from whence the abſorbent veſſels ariſe, the trunks of which run on the plain or flat ſide of the ſpleen, between the two membranous coverings, of which we have already ſpoken.

§ 399.

§ 399.

This texture of the ſpleen, ſo very lax and highly capable of admitting blood, correſponds admirably with what we formerly ſaid reſpecting the ſanguineous diſtenſion of this viſcus (§ 395): and we may further obſerve, that the phenomena of the congeſtion, and tardy progreſſive motion of this crimſon fluid in the ſpleen, conſidered in conjunction with the nature of the ſurrounding and contiguous viſcera, tend not a little to illuſtrate the peculiar ſtate and condition of the ſplenic blood, which of themſelves appear to ſhed conſiderable light on the *function* of this myſterious viſcus, a ſubject of ſuch repeated controverſies among phyſiologiſts.

§ 400.

The blood contained in the veins of the ſpleen is very fluid, diſſolved, coagulated with the utmoſt difficulty, and admits of but a ſlight and partial ſeparation of the ſerum from the craſſamentum; its colour is alſo livid and obſcure, as in the fœtus; all which phenomena appear evidently to combine in aſcertaining and even demonſtrating the preſence of an abundant quantity of the phlogiſtic element. That this element is, however, unequivocally preſent in large quantities, I further aſcertained to my entire ſatisfaction, by the following ſimple and concluſive experiment: to the ac-

tion of pure dephlogifticated air, I expofed recent fections and flices of the fpleen of a human fubject; no fooner were thefe pieces brought in contact with this vital fluid, than they were overfpread with a very florid and beautiful crimfon blufh, while the air itfelf, thus defpoiled of its native fire, was on the other hand, contaminated by the fplenic phlogifton.

§ 401.

When we contemplate the foregoing circumftances collectively, and confider in the laft place, that the *fpleen* is the only vifcus of a fimilar nature wholly unfurnifhed with any veftige of an excretory duct, fave thofe veffels which we have already faid run to the liver, we are obliged from the force of concurring teftimony to conclude, that the fole office of the organ now under confideration, is to act in fubferviency to the function of the liver, and contribute towards the formation of bile by the co-operation of its phlogiftic parts.

§ 402.

This opinion is ftill farther fubftantiated by a very curious and ufeful obfervation, made on fuch individuals of the animal kingdom, as have been deprived of the fpleen by excifion. It appears that in animals fubjected to this operation (which, however fingular and feemingly barbarous, has

been, notwithſtanding, very frequently performed from remote periods of time) the cyſtic bile has been uniformly afterwards found to be pale, weakly impregnated with phlogiſton, and diſpoſed to a grume-like coagulation of its lymphatic portion.

SECT. XXXII.

OF THE FUNCTION OF THE OMENTUM.

§ 403.

THE *omentum gaſtrocolium*, or *omentum magnum*, (ſo called to diſtinguiſh it from the *parvum* or *hepaticogaſtricum*), is indeed a very ſingular production of the peritoneum, originating immediately from the external coat of the ſtomach.

§ 404.

For notwithſtanding the continuations of the *peritoneum*, in the abdominal cavity, be almoſt innumerable, and although all the parts contained in this cavity, whether viewed collectively or individually, be ſo uniformly inveſted by it, that, on opening the abdomen, it is impoſſible to diſcover a ſingle viſcus which this membrane does not embrace, yet the modes in which it furniſhes this covering

covering to the ſeveral viſcera, are ſo diverſified, as to merit a diviſion into different claſſes.

Thus, for example, the abdominal cavity contains certain parts, over which the peritoneum is only ſpread in ſuch a partial and ſimple manner, as to inveſt but one of their ſurfaces; this obſervation may be applied particularly to the kidneys, the *inteſtinum rectum*, the *veſica urinaria*, and in ſome meaſure alſo, to the pancreas and gall-bladder.

There are alſo other viſcera, which, notwithſtanding their attachment and adheſion to the ſurrounding parietes of the abdomen, yet project alſo to a conſiderable diſtance into the abdominal cavity itſelf, and derive from the peritoneum a covering, which inveſts, by far, the greater part of their external ſurfaces: of this deſcription are the liver, the ſpleen, and even the ſtomach and female uterus, to which we may add, finally, the teſtes of a male fœtus, previouſly to their deſcent into the ſcrotum.

Conſiderably different again, (in point of peritoneal covering), from both the foregoing claſſes of viſcera, is the whole of the inteſtinal tube, except that portion which is denominated *inteſtinum rectum*. This tube paſſes through the adominal

cavity in ſuch a manner, as to carry along with it, two remarkably broad proceſſes of the peritoneum, namely the *meſentery* and *meſocolon*, to which it adheres in a ſtate of ſuſpenſion: under the ſame claſs with the two preceding proceſſes, may we alſo arrange thoſe ſingular peritoneal productions, denominated the broad ligaments of the uterus.

§ 405.

But finally, the moſt extenſive of all is that peculiar continuation of the peritoneum called the *omentum*. This production is a large empty ſac of a very delicate texture, that hangs in a depending poſition from the great curvature of the ſtomach; it is ſpread over the region of the *ſmall inteſtines* in particular, nicely adapts itſelf to their irregular convexities, and dips down, in ſome meaſure, into their numerous interſtices.

§ 406.

Beſides the blood veſſels by which the omentum is painted, it is alſo marked by numerous *ſtriæ* or *broad lines* of adipoſe ſubſtance, which meet, interſect, and thus form a variety of reticular intertextures, from whence the membrane has received the name *vernaculum*. In perſons diſpoſed to obeſity this adipoſe ſubſtance encreaſes now and then to ſuch a ſize, as to become not only troubleſome but even dangerous: it is alſo this

adipoſe

adipofe portion that affords origin to that oily halitus by which the omentum is conftantly furrounded and moiftened.

§ 407.

It has been the opinion of certain celebrated characters, and a further attempt was made by the illuftrious Haller to prove, that the fat contained in the omentum is deftined to be taken up by abforption and conveyed to the liver, for the purpofe of fupplying the bile with its oily portion, &c. With refpect to the truth of this opinion, however, I muft ftill be permitted to entertain and exprefs a ferious doubt, having never yet been convinced that found, uncontaminated, bile contains any oil; nor have I ever been able to difcover any orifices fubfervient to fuch an abforption, not even in frogs themfelves, where Malpighi alleged, and even attempted to prove, their exiftence; much lefs in that part which is the fubject of our prefent confideration, namely, the omentum of man.

§ 408.

What appears, from the nature and fituation of the part, as well as from the concurring belief of all phyfiologifts of the prefent day, to be a much more unequivocal ufe of the omentum, is, to lubricate the inteftines, and by that means aid and

facilitate their perpetual motion. The ſame appear alſo to be the uſe and deſtination of certain ſimilar, but ſmall, adipoſe *burſæ*, by which the *colon* and *rectum* are inveſted.

The omentum alſo further ſerves to prevent the occurrence of an adheſion between the inteſtines and peritoneum, by which the whole office of the primæ viæ would be ſubverted.

§ 409.

That this adipoſe curtain is deſtined to ſerve as a defence againſt cold, (though an opinion very generally received), appears, notwithſtanding, to reſt on evidence of a more queſtionable nature: the omentum of a man in perfect health, which ought by no means to be burthened with an accumulation of fat, is indeed, but very illy calculated to anſwer ſuch an intention.

When we conſider, in the mean time, the ſingular ſtructure of the two *omenta*, more eſpecially of that denominated *omentum parvum* or *gaſtrohepaticum*, it appears ſufficiently probable, that beſides the uſes already enumerated, the latter is ſtill deſtined for another, of, perhaps, even *ſupreme importance*, which is as yet unknown to us, and which future reſearches in comparative anatomy will be alone able to develope.

SECT.

SECT. XXXIII.

OF THE FUNCTIONS OF THE INTESTINES.

§ 410.

THE inteſtinal tube itſelf (before which the omentum is ſpread, and into which we have already ſeen the chyme conveyed, in order to be further elaborated and ſufficiently fitted for the ſeparation of chyle), is divided into two leading portions, namely, the *ſmall* and *great*; of the functions of which we will now treat ſeparately and in order.

§ 411.

The *ſmall* portion of inteſtines is again ſubdivided into three parts, namely, the *duodenum*, *jejunum*, and *ilèum*.

The duodenum derives its name from the circumſtance of its length.

The jejunum from that of its general habit, becauſe, in a recent corpſe, it appears collapſed and empty as it were, even although it contain at the ſame time a quantity of pulpy chyme. In the third diviſion, called *ileum*, the chyme depoſits its fæces, and ſuffers an evolution of its air, which

had been hitherto fixed, fo that this laft of the fmall inteftines, being at the fame time the longeft, and deriving its name from its circumvolutions, appears more turgid, fomewhat inflated, and marked here and there with fmall bubble-like eminences, after the manner of the large portion of this tube.

§ 412.

The coats of the fmall inteftines are perfectly fimilar to thofe compofing the ftomach, of which we have already fpoken (§ 359.)

The *external* is a production of the mefentery.

The *mufcular* coat confifts of two orders of fibres, to wit, *longitudinal*, which are interrupted in their courfe, and run rather *externally*, efpecially on that fide of the inteftine that looks in a contrary direction from the mefentery; and more *internal*, *annular*, or *falciform* fibres, which are calculated to contract or narrow the diameter of the tube; whereas the former are intended to diminifh its longitudinal extent. On both the preceding orders of fibres depends that exquifitely energetic and pertinacious *irritability* of the inteftines, of which we have fpoken on a former occafion (§ 306.)

The

The *nervous* coat confifts of compacted cellular membrane; and may, by a very fimple mode of treatment, efpecially by blowing into it, be again reduced to a fpongy, foam-like tiffue: throughout this coat a variety of blood-veffels, detached from the mefenteric, are diftributed in the form of arborets or branching fhrubs, of inimitable elegance and beauty. As in the ftomach, fo likewife in the inteftines, the nervous coat is the principal feat of tenacity and ftrength.

Finally, the internal coat (which merits more unequivocally, in the fmall inteftines, than in any other part of the alimentary canal, the name *villous*), is continued here and there, in conjunction with the internal furface of the preceding membrane, into wave-like productions and rugous folds, that in the inteftines, when inflated and dried, exhibit a falciform appearance, and are denominated valvulæ Kerkringii.

§ 413.

Of the *villi* themfelves, an immenfe number overfpread, in the clofeft order, the whole internal furface of the fmall inteftines: their fubtle and exquifitely elegant vafcular ftructure, was firft difcovered and demonftrated by the labours of the indefatigable Leiberkuhn. While the inteftines are deftitute of chyle, the *villi* may be compared in

in ſome meaſure to ſmall purſes hanging in a looſe and flaccid poſition, and conſiſting internally of a ſoft ſpongy texture; but when they become turgid, in conſequence of the abſorption of this milky fluid from the inteſtinal canal, their figure undergoes ſuch a ſtriking change, as to bear no ſmall reſemblance to the *phallus eſculentus* *.

§ 414.

Thoſe *villi* are ſurrounded, at their baſes, by an infinitude of *ſmall glandular follicles*, which are lodged principally in the nervous coat, and communicate by very minute orifices with the inteſtinal cavity, into which they diſcharge a mucus that ſerves to line and lubricate the whole internal ſurface of that tube.

Theſe minute glands are commonly ſuppoſed to conſiſt of three orders. *Firſt*, the Brunnerian or larger glands, which are ſeparate from each other, and ſituated principally on that part of the duodenum, which lies next to the pylorus.

Secondly, the Peyerian, which are conſiderably ſmaller, planted in cluſters, and lodged, in particular, on the other extremity of the ſmall inteſ-

* A ſpecies of *fungus*, denominated *phallus*, from its ſtriking ſimilitude to the male penis.

tines, which looks towards, and is contiguous to, the valve of the colon.

And, *laſtly*, the glands of Leiberkuhn, the moſt minute of all, of which about eight are ſaid to belong to each *villus*.

It ought to be obſerved, however, that this diviſion of the ſources of mucus appears to reſt on very equivocal evidence. For if I be not greatly deceived, both the Brunnerian and Peyerian glands, as commonly exhibited in plates, are the reſult of a vitiated and diſeaſed ſtate of the inteſtinal tube. I am induced to entertain this opinion from having never been able to diſcover, in the ſound ſmall inteſtines of ſubjects carefully examined in different periods of life, the ſmalleſt veſtige of ſuch fungous papillæ, perforated with orifices; whereas, on the other hand, I have frequently ſeen, in caſes of *aphtha*, almoſt the whole inteſtinal canal planted with countleſs numbers of them, partly ſtanding alone, and partly arranged in crouded cluſters. From conſidering the foregoing circumſtances, I feel a confidence in concluding, that none can be accounted true muciferous glands, except thoſe extremely minute miliary bodies, which, on gently ſeparating the *villous lining*, may be readily detected on its *averted ſurface*, but

cannot,

cannot, without great difficulty, be diſtinguiſhed on the ſide next to the eye.

§ 415.

It has been incontrovertibly eſtabliſhed, not only from that well known experiment firſt inſtituted (if I miſtake not) by Pechlin, but alſo from ſeveral others, that as the ſtomach, ſo in like manner the cavity of the ſmall inteſtines, is ſupplied with a conſtant influx of a liquid, denominated, from the place into which it is diſcharged, *inteſtinal juice*. It appears probable that this fluid is ſimilar in its nature to the gaſtric liquor, although a more accurate inveſtigation of it is, certainly as yet, a deſideratum in phyſiology: neither can I venture to ſay any thing deciſive reſpecting the *quantity* of this liquid ſecreted: I am, however, fully of opinion, that Haller has been too profuſe in his eſtimate, where he alleges, that this ſecretion amounts to eight pounds in the ſpace of twenty-four hours.

§ 416.

Further, it is alſo common to the inteſtines with the ſtomach, to be agitated by a *ſimilar*, but far more *lively* and vigorous *periſtaltic motion*, which, in particular, while the chymous pulp is advancing onward, throws the ſame into gentle commotion, by

by a wavy and progreſſive conſtriction, and thus propels it forward from the duodenum towards the great inteſtines. For although we cannot abſolutely deny the phenomenon of an anti-periſtaltic commotion, in conſequence of which the inteſtines are ſubjected to a retrograde action, it muſt, notwithſtanding, be acknowledged, that this, in a healthy ſubject, is much feebler than the former, that it occurs more rarely, and poſſeſſes a more precarious and ſhort-lived exiſtence.

§ 417.

In conſequence of the co-operation of thoſe energetic cauſes, hitherto enumerated (viz. both the *principles* of *motion*, of which we have juſt ſpoken, and likewiſe the *ſolvent* and *alterative* powers of the inquiline humours that are every where blended in abundance with the chyme), the following remarkable changes are produced in this heterogeneous maſs :—in the jejunum it exhibits the appearance of a more liquid pulp, poſſeſſing a colour ſomewhat grey, and an odour ſlightly acid: after its entrance into the ileum it begins to ſeparate into two portions ; theſe are, *firſt*, the *fæces*, marked by a pale yellow colour, inclining more or leſs towards a brown, and poſſeſſing a fetid odour ; and, *ſecondly*, a white milk-like fluid, denominated *true chyle*, which floats on the ſurface of the fæces, and is ſeparated from them by the action

action of the hepatic liquor or bile. This chymous emulsion, designated by the name of chyle, is destined to be received by *absorption* into the *lacteal vessels*, through which mazy tubes we will accompany it farther in the *following section*; and shall, in the mean time, close the *present*, by tracing, in as brief and intelligible a manner as possible, the route pursued by the residuary fæces.

§ 418.

These, therefore, after having become more and more inspissated, in consequence of a tedious course through the ileum, are obliged at length to pass the valve of the colon, and thus enter the tract of the *great intestines*; for which purpose the neighbouring extremity of the ileum is furnished, and lubricated internally, by a more copious quantity of mucus, destined to destroy the friction of the fæces, and consequently facilitate their transition through the foregoing valve.

§ 419.

The *valve of the colon* (denominated very justly in honour of its real and illustrious discoverer, *valvula Fallopii*), is a short continuation or process of the *ileum* projecting into the cavity of the great *intestinal portion*, by which it is surrounded and closely embraced: the more exterior *labia* of this *process* are so constituted, by means of a more prominent

prominent or extenſive ruga of the *great inteſtine*, as to conſiſt not only of its internal and nervous coats (as is the caſe with the greater number of ſuch plicæ), but to contain alſo in its compoſition ſome fibres from the muſcular coat. Hence the function of this valve appears to be twofold, to prevent the premature paſſage of the fæces from the ſmall into the great inteſtines, and alſo to obſtruct their regurgitation from the latter into the former.

§ 420.

The great inteſtinal portion, which in like manner with the ſmall, is alſo divided into *three ſections*, begins from the *cæcum* (to which is appended the *vermiform proceſs*, a part indeed of equivocal uſe in the economy of an adult ſubject), and conſtitutes collectively a canal ſo capacious, as to admit the inſpiſſated fæces to be gradually collected and retained in its cavity, till a convenient opportunity for their evacuation.

§ 421.

As the *great* is ſuperior to the *ſmall* portion of the inteſtines in diameter, ſo it likewiſe exceeds it in the thickneſs and ſtrength of its coats. The muſcular coat, in particular, poſſeſſes this peculiarity, that its longitudinal fibres (if we except the lower part of the rectum) are collected into three

faſciculi

fasciculi or bundles, called *ligamenta coli ;* aud the colon itself is thus divided into distinct segments of a vesicular or cystiform appearance. The internal coat in the *great*, is not of such a beautiful and elegantly floccose appearance as in the *small* intestines, but possesses a nearer resemblance to that which invests the cavity of the stomach.

§ 422.

The peristaltic motion appears to be less vivid and active in the great, than in the small intestines. On the other hand, the *abdominal pressure* is considerably greater on the former than on the latter, in as much as the whole *colon* is subjected to its immediate action and influence.

§ 423.

The inspissated and hardened fæces contained in the large intestines, are protruded slowly onward, till having at length reached the rectum, they excite, by their stimulus on the internal surface of that tube, a propensity to an evacuation. For the purpose of facilitating this evacuation, ample and wise provision is made, partly by a defect or interruption in the transverse rugæ, but more especially by a profuse quantity of mucus, that lubricates the internal surface of the rectum near to its extremity.

The evacuation of the fæces is, however, principally accomplished by a downward direction of the abdominal pressure, overcoming the resistance of the coccyx and both the sphincters, the interior of which is a very singular fascisculus or bundle of annular fibres, but the exterior, a genuine cutaneous muscle: these ends being quite completed, there succeeds an entire remission of the abdominal effort, the intestine is retracted by the *levator ani* in particular, and finally closed again by the contraction of the sphincters.

SECT. XXXIV.

OF THE FUNCTIONS OF THE ABSORBENT SYSTEM.

§ 424.

FROM observations delivered in a former section it is sufficiently evident, that the chyle, which we left in the *intestinum ileum*, completely disengaged from its fæces, is a compound of several different humours. Although it be almost literally impossible to calculate, with accuracy and definitude, the precise quantity of *inquiline humours*, such as saliva, gastric juice, pancreatic juice, intestinal juice, bile, &c. that is mixed and blended

with the chyme, it appears, notwithſtanding, a matter of the higheſt credibility, that theſe ſeveral humours, taken collectively, very far exceed, in quantity, the other conſtituent part of the chyle, which is derived immediately from alimentary ſubſtances, recently taken as nutriment. Hence we may derive a ſolution of that problem in phyſiology, by what means alimentary matters, though of the moſt different and even oppoſite kinds, may, notwithſtanding, be converted into the ſame aſſimilized, homogeneous, and milk-like chyle, equally adapted to the *nature*, and calculated to ſerve as the *nutriment*, of animals?

§ 425.

The *channels* through which the chyle muſt flow, in its paſſage from the inteſtines to the *maſs of blood*, (the reſervoir deſtined for its ultimate reception), conſtitute a part of the *abſorbent ſyſtem*, which we have hitherto mentioned only occaſionally, and in a very curſory manner, but will now aſſume as the profeſſed object of our preſent attention. This ſyſtem is divided generally into four parts, viz. lacteal veins; lymphatic veins; conglobate glands; and finally, the thoracic duct, each of which ſhall conſtitute a ſubject of excluſive conſideration.

§ 426.

§ 426.

With reſpect to the naſcent origin of the lacteals from the inteſtines, there exiſts ſcarcely a doubt, but that this is conſtituted by the innumerable *villi* of the internal inteſtinal coat, of which we have already ſpoken. It is, however, ſtill a matter of controverſy, whether the lacteals originate immediately from thoſe villi themſelves, or only preſerve a more diſtant intercourſe and communication with them, by means of interjacent cellular ſubſtance. As far as my information has extended, no one has hitherto been able, more than myſelf, to trace the evaneſcent radicles of the lacteal veſſels to the villi themſelves, with ſuch clearneſs and definitude, as to diſcover an immediate and unequivocal connection between the parts; on the other hand, the lacteals appear here and there, throughout the coats of the inteſtines, to form trunks of conſiderable ſize, immediately after their orgin, and, (if a conjecture be allowable), to abſorb from the cellular ſubſtance of the adjacent parts, that chyle which had been originally taken up from the cavity of the inteſtines by means of the villi themſelves. This phenomenon I think I have frequently obſerved, in young puppies, into which I had poured, according to the celebrated experiment of Liſter, a ſolution of Indian blue, one or two hours before ſubjecting them to the operation of *live-diſſection*.

§ 427.

Thofe trunks, of which we have juft fpoken, frequently run the diftance of feveral inches, and fometimes even wind about in angling or meander-like directions, immediately under the external coat of the inteftine, previoufly to their entrance into the mefentery.

§ 428.

During their paffage through the mefentery, thefe trunks make frequent entrances into fmall *mefenteric glands*, which may be divided into two different *feries* or *orders*. Thofe of the firft order are fituated in the vicinity of the inteftinal tube, and refemble, in their appearance, fmall beans lying feparate from each other. The glands of the other order, lie nearer to the receptacle of the chyle, are fuperior in magnitude, and planted in collective clufters.

§ 429.

Both the foregoing kinds of glands appear to be in reality nothing elfe, than round compacted convolutions of the lacteal veffels themfelves, covered and interfperfed with an infinitude of minute blood-veffels: their deftination appears to be, to retard the progreffive motion of the *chyle*, in order, perhaps, that, by fuch delay, it may be more fully and perfectly animalifed and matured, previoufly

ously to its entrance into the thoracic duct, and subsequent admixture with the circulating volume of the blood.

§ 430.

It has been proposed as a physiological question, whether or not the *large*, possess also lacteal veins, in common with the *small* intestines? The affirmative of this has been zealously advocated, and its defence attempted by arguments drawn from the influence and efficacy of specific enemas, of enemas composed of nutrimental substances, of inebriating substances, &c. and also from the following well known circumstance, viz. that the longer inspissated fæces are retained in the large portion of the alimentary canal, the more indurated and insucculent they are uniformly found. But although these arguments do not satisfactorily demonstrate that any genuine chyle is absorbed from the fæces after their transition over the valve of Fallopius, they furnish, notwithstanding, additional evidence in confirmation of that, which has indeed been long since established on the testimony of the sense of vision itself, namely, that the great intestines abound with a sufficiently plentiful apparatus of lymphatic veins, perfectly similar to the lacteals both in their structure and functions: in testimony of this entire similarity, it may be proper to observe, that when the intestines are destitute

of chyle, the lacteals of the mefentery are then engaged in the abforption of lymph.

§ 431.

Another queftion, more important and difficult of folution than the former, is, whether or not the whole of the chyle, abforbed from the cavity of the fmall inteftines, be conveyed to the blood through the fame *public*, and *royal* route, as it is termed, or whether there do not exift certain fecret channels, through which it may glide furreptitioufly onward, to mingle its ftreamlets with the general current of circulating blood?

It muft indeed, be confeffed, that moft of the arguments, by which phyfiologifts have endeavoured to prove a private abforption and conveyance of chyle through the fanguiferous veins, do not appear to reft on a very folid foundation: thus the affertion of Ruyfch, that on the approach of old age the mefenteric glands become fo indurated and conftricted, as to be rendered unfit for performing their functions, has been long fince refuted, and it has, on the other hand, been fatisfactorily demonftrated that, different affections of thefe glands, fuch as fwellings, &c. very erroneoufly pafs under the common name of *obftructions*, while, at the fame time, their veffels remain in a ftate fufficiently pervious to afford a very eafy entrance

trance and tranſition to injections of quick ſilver. That well known phenomenon, from which it is aſcertained, that tepid water, thrown into the inert meſenteric veins of a dead ſubject, tranſudes into the cavity of the inteſtines, appears to contribute but very little towards the ſatisfactory elucidation of any function of the human body while in a living ſtate; much leſs can we repoſe confidence in the evidence derived from that *bicrural* and *two branched* tube of copper, which was invented by Lieberkuhn, for the purpoſe of confirming the ſame opinion. As to the aſſertion, that chyle has been unequivocally detected in the red veins of the meſentery, it appears to me to ſtand in need of farther evidence for its unqueſtionable confirmation; on the whole, I have never yet been convinced, that thoſe veins convey any thing elſe than blood very highly charged with phlogiſton, deſtined for the ſecretion of bile.

§ 432.

Finally, the ultimate trunks of the lacteal veins, (with certain other tubes very ſimilar in appearance and function, which are formed by the confluence of a great number of minute lymphatic veſſels), unite and conſtitute by their junction, the *receptacle* or *ciſtern of the chyle*, which is a name given by phyſiologiſts to the inferior and larger

portion of the *thoracic duct*, called alſo the *duct of Pecquet*.

§ 433.

This duct is a membranous canal, of a delicate appearance and texture, yet ſufficiently robuſt and ſtrong, more or leſs circuitous in its courſe, and not unfrequently ſubject to very ſtriking diverſities with regard to the direction in which it runs, and the diviſions it occaſionally undergoes: it is equally deſtitute of muſcular fibres and nerves, is furniſhed here and there with ſmall valves, and, after having paſſed over the *left ſubclavian vein*, is again reflected towards, and finally inſerted into, the *ſame*, and, at the very point of inſertion, has its entrance guarded by a valve of a peculiar ſtructure.

§ 434.

The powers which produce and continue the onward motion of the chyle, both in the lacteal veins, and through the thoracic duct, are to be attributed, indeed, principally to the contractility of theſe veſſels themſelves, but, in part alſo, to the valves with which they are furniſhed, to a propulſive *vis a tergo*, and to the uninterrupted pulſation of neighbouring arteries.

§ 435.

§ 435.

It appears probable, that the principal deſtination of the valve, which is fixed, as has been already obſerved, in the entrance of the chyliferous duct into the ſubclavian vein, is not ſo much to obſtruct the lateral paſſage of blood into this duct, as to regulate the neceſſary diſcharge of chyle into the vein, and prevent its admiſſion in any other manner than by a ſlow and gradual ſtillicidium.

By this means, adequate proviſion is made againſt the ſimultaneous entrance of too large a quantity of recent chyle, into the maſs of blood. Such an exceſſive influx of this crude fluid would neceſſarily ſtimulate the *parietes* of the heart to exertions too violent and laborious, and would be blended and aſſimilated by the ſame, with the utmoſt difficulty, and in an imperfect manner; that this would be the reſult, we judge from the nature of recent chyle, which is a compound of heterogeneous elements, derived not only from the *primæ viæ*, by means of the *lacteal*, but alſo from all the other parts of the body, through the avenues of the *lymphatic veſſels*.

§ 436.

The *lymphatic veins* themſelves, which conſtitute a third part of the abſorbent ſyſtem, and bear a very

a very clofe refemblance to the lacteals, both in ftructure and in function, are fo confiderable, in point of extenfion, as to pervade, perhaps, every part of the human body; but originate, in particular, from the common external integuments, from the pleura, the peritoneum, and vifcera, contained in the thorax and abdomen.

§ 437.

The manner in which they arife, is fimilar to the origin of the lacteals from the inteftines, of which we have already fpoken. Thus each radicle of each lymphatic veffel, is deftined to abforb from a neighbouring portion of cellular membrane, (as from a territory of its own), the moifture it contains, and propel it onward to the general ciftern of the chyle.

§ 438.

Thefe *lymphatic veffels* are furnifhed in their courfe, fometimes more frequently, fometimes more rarely, with valves fituated in *bigæ* or *pairs*. By far the greater part of them enter conglobate glands; thofe in the vicinity of each other frequently anaftomofe; and fuch of them as overfpread the furface of certain vifcera, as that of the lungs, the liver, &c. form exquifitely elegant reticular expanfions.

§ 439.

§ 439.

To paſs ſilently over certain other aids, ſufficiently evident from former obſervations, the function of the lymphatics is greatly promoted by their remarkable contractility, and the *ſtrength* of their delicate coats, which is ſufficient, in proceſſes for anatomical preparations, to reſiſt the preſſure from a ponderous column of quick ſilver: this function is alſo further aided, eſpecially in the joints, by *muſcular motion*, in conſequence of which, the lymphatics being compreſſed and cloſely embraced on all ſides, have their tone remarkably augmented.

§ 440.

With reſpect to the terminations of the lymphatics, various controverſies have lately exiſted among phyſiological writers. Thus, while ſome contend, that all thoſe veſſels unite in the thoracic duct, (in like manner as the ſanguiferous veins unite in the venæ cavæ), others, on the contrary, exempt from this general confluence, at leaſt the lymphatics of the right arm, and right ſide of the neck, which they allege are not inſerted into the ſame duct, but into the right ſubclavian vein: others again aſſert that in the conglobate glands, the lymphatics communicate immediately with ſanguiferous veins; and laſtly, others maintain (not indeed without an appearance of probability) that certain

certain lymphatic veſſels *, actually exiſt, which form a direct and free communication between the inteſtinal tube and uropoietic organs.

§ 441.

Seeing therefore, the lymphatic veſſels are extended far and wide throughout almoſt the whole ſyſtem, and, eſpecially, in as much as an immenſe profuſion of them originate on the cutaneous ſurface of the body, and may conſequently abſorb ſuch fluids as are applied from without, it is ſufficiently evident, that the lymph, when recently abſorbed, muſt be, indeed, a liquid compoſition extremely heterogeneous and diverſified as

* For a great number of truly important obſervations and highly intereſting ſpeculations on this ſubject, the reader is referred to a ſhort treatiſe, written by Charles Darwin, "On the retrograde motion of the lymphatics," and publiſhed at Litchfield in the year 1780, a conſiderable period of time after the premature death of its ingenious author. This young philoſopher and phyſician appears to have been peculiarly formed by nature, and happily finiſhed by education, to ſhed unequivocal light on ſubjects of a dark and difficult nature in the ſcience of medicine. He experimented with accuracy and definitude, he obſerved with the utmoſt attention, and he ſpeculated with the higheſt ingenuity and force. Unhappily for the *healing art*, and (perhaps I may add) for *ſcience* in all its various branches, this amiable young philoſopher was haſtily ſummoned away, ere yet his mind was perfectly expanded, or his plenitude of merit announced to the world.

to

to its nature and elementary parts: this diverſity is fully aſcertained and eſtabliſhed, by a more careful and accurate examination of dead ſubjects, where, for inſtance, the liquid contained in the abſorbents of the liver and ſpleen, appears to be evidently different from that diſcovered in thoſe which run to the uterus.

§ 442.

Of the *conglobate glands*, (which conſtitute the laſt branch of the lymphatic ſyſtem), the principal uſe and deſtination appear to be, to aſſimilate to the animal nature this ſubtle and heterogeneous fluid, eſpecially that portion of it which is abſorbed by the lymphatics of the ſkin: this aſſimilation they accompliſh by retarding and in ſome meaſure obſtructing the motion of the lymph, and perhaps alſo by the addition of a new fluid, derived from the minute arteries, with which they very plentifully abound. Hence a wiſe and adequate proviſion is made, to prevent the *humours*, while in too crude a ſtate, from effecting a premature mixture with the blood, and thus the heart is guarded in perfect ſecurity from their noxious impreſſions.

§ 443.

With reſpect to thoſe other glands of the ſame nature, which are minutely diſpread throughout

by

by far the greater part of the fyftem, and planted here and there in collected clufters, as in the groin, beneath the axilla, &c. they bear, in every refpect, the moft perfect refemblance to the mefenteric glands, of which we have already fpoken; like them they are compofed, in a great meafure, of the mazy convolutions of abforbent veins; like them they are furnifhed with a vaft profufion of minute blood veffels; and finally, they are fubject to be readily invaded by the fame difeafes that attack the glands of the mefentery.

SECT. XXXV.

OF SANGUIFICATION.

§ 444.

IT is fcarcely neceffary to obferve, that by the term *fanguification*, we mean the affimilation of *chyle* to *blood*, and the conftant and uniform reftitution made by means of the *former*, for the equally conftant and uniform lofs which is fuftained by the *latter*.

§ 445.

For on this *principle* depends that divifion of all the humours of our body, into the three claffes

(§ 4.

(§ 4. 5.) of *crude*, *ſanguineous*, and *ſecreted*; viz. that the middle claſs embrace the whole circulating volume of blood, from which the different ſecreted humours are derived in conſtant ſtreamlets, and to which the countleſs channels of the abſorbent ſyſtem convey their chyle, and the infinitude of lymphatic tubes return their abſorbed fluids in currents equally conſtanr and uniform.

§ 446.

Seeing the blood is an animal humour of ſo very ſingular and excluſive a kind, as to be wholly diſſimilar to every other fluid yet diſcovered in any department of nature, it is a propoſition ſufficiently ſelf-evident, that there muſt be a variety of aſſiſtant powers which contribute, by their joint cooperation, to incorporate and aſſimilize with the blood, the heterogeneous and adventitious humours, which it is conſtantly deriving from the thoracic duct.

§ 447.

The proceſs of ſanguification we may conſider, then, as firſt commencing under the action and influence of thoſe mazy circumvolutions (frequently ſpoken of already), which both the lacteal and lymphatic veins exhibit occaſionally in their courſes (more eſpecially in the meſenteric and other con-

globate glands), and which are, at the fame time, furnifhed with confiderable quantities of what may be called *animal* and *inquiline contagion.*

§ 448.

It is neceffary further to confider, that a great part of the lymph, which enters the fubclavian vein (after having firft effected a mixture with the inteftinal chyle in the thoracic duct), is derived from the interior receffes of the vifcera and other foft parts of the body, and was formerly fecreted from the blood itfelf; from whence it neceffarily follows, that fuch portion of the lymphatic fluid muft doubtlefs poffefs, already, the animal nature entire, and be very readily mifcible with the mafs of blood to which it is returned.

§ 449.

To thefe we may add another circumftance, of which we fpoke on a former occafion, namely, the flow and ftillicidious tranfition of the *chyle* into its refervoir, the *blood*—that fluid not being admitted to pafs through the ultimate valve of the thoracic duct into the fubclavian vein, in any other manner than by drops, in order that thofe minute portions may, by this means, be more intimately mixed and incorporated with the circulating blood.

450

The internal ſtructure of the heart itſelf appears alſo to contribute, not a little, towards the important proceſs of ſanguification. Thus, by means of thoſe aſtoniſhing muſcular papillæ, with which the ventricles of the heart are plentifully furniſhed, the blood and chyle (having recently met together), are thoroughly agitated, and brought into a ſtate of more intimate combination.

§ 451.

That the *lungs*, receiving the blood, recently impregnated with chyle, perform, by the function of reſpiration, an important part in the further aſſimilation of this crude fluid, will appear ſufficiently evident to any one who conſiders the aſtoniſhing vaſcular ſtructure of theſe viſcera (§ 136.) in conjunction with the equable alternate motion to which they are perpetually ſubjected, during the continuance of human life.

§ 452.

The remaining part of the proceſs of ſanguification is finally completed by the more extenſive circuitous journey of the blood throughout the whole body, and by thoſe powers which contribute towards the continuance of the ſame, more eſpecially *muſcular motion*, &c.

§ 453.

But although potent provision be made, by such powerful and diversified *apparatus*, for blending and intimately incorporating the chyle with the blood, it appears, notwithstanding, that there exists a certain similarity between the constituent parts of those two fluids. It is very commonly asserted, that a great many hours must elapse before the chyle can be completely divested of its own milky colour, and perfectly assimilated to *that* of the crimson fluid into which it is destined to be converted: in testimony of the truth of this assertion, medical philosophers usually adduce (besides other arguments) the following singular pathological phenomenon, namely, that several hours after the close of digestion, genuine chyle has been frequently observed to flow from an orifice made in a vein of the human body: this phenomenon I have indeed had an opportunity of observing myself; but it was at the same time extremely evident, that the blood was then highly charged with phlogiston (a condition of this fluid very unfriendly to the regular assimilation of chyle), so that from hence scarcely any inference can be drawn relative *to the healthy state* of the system, which is alone the exclusive subject of the science of physiology.

SECT.

SECT. XXXVI.

OF NUTRITION.

§ 454.

BESIDES *that function* (which we attributed to the blood in a former section) of distributing the element of *fire* throughout the whole body, and in *its* place wafting that of *phlogiston* back to the lungs, two of its primary and leading offices appear to be, to convey to the body nourishment, and to the secretory organs the matter of those peculiar fluids which they are severally destined to extract. Of this twofold function we will next treat; and *first* of the function of *nutrition*.

§ 455.

Nutrition is the supreme privilege of nature. It is a common and leading prerogative of all organized bodies, whether animal or vegetable, by which they are instantly discovered, on first view, to surpass, in an immeasureable degree, all machines and automatons constructed by human artifice: because on none of these latter has any artist ever been able to confer a power (I will not say of actual *growth*, of progressing toward *maturity*, and of acquiring gradually higher and higher

degrees of *perfection)*, but not even of preferving themfelves in a ftate of *ftationary exiftence* by their own inherent powers, nor of repairing the gradual loffes to which they are fubjected by attrition, by incidental cafualties, &c.

§ 456.

Nutrition is that faculty of our bodies, on which all the fublime and aftonifhing functions of our nature depend. By means of this faculty we increafe in magnitude from the earlieft dawnings of our exiftence, we advance through the expanding period of youth, and finally arrive at our *acme*, or point of complete maturity. It is alfo through the inftrumentality of this fame faculty that a competent remedy is applied, and fufficient reftitution made, for that uniform wafte and lofs of the body, by which (while in a living ftate) it deftroys and in fome meafure confumes itfelf, by its own neceffary action.

§ 457.

With refpect to the nature and mode of this *wafting* or lofs, various controverfies have exifted among phyfiologifts. The more immediate point of difputation has been, whether fuch wafte occurs in the folid parts of our bodies, or whether it be not more probable, that thofe parts, when once formed and completed, remain ftationary, without

being

being ſubject either to vitiation or change? which latter is indeed an opinion embraced and taught by ſeveral characters of the utmoſt acumen and ingenuity.

§ 458.

With reſpect to ſome particular ſolid parts of the body, ſuch, for example, as the epidermis, the nails, &c. there exiſts indeed not a ſhadow of doubt, but that they are gradually deſtroyed and again repaired; and with regard to the deſtruction or waſte and ſubſequent reparation of the bones themſelves, the teſtimony will appear equally plain and concluſive, to any one who may conſider with attention the reſult of the well known experiments made by feeding warm-blooded animals, for ſome time, on the root of the *rubia tinctorum*, or who may take the further trouble of contemplating attentively the phenomena exhibited by certain large plain bones, eſpecially thoſe of the cranium, which in extreme old age become remarkably attenuated, or diminiſhed in thickneſs, in conſequence of the ſcanty nouriſhment with which they are ſupplied at that period of life.

§ 459.

Upon the whole, if I be capable of judging rightly, thoſe ſolid parts appear to be not only gradually conſumed, and again repaired, by the

faculty of nutrition, but poſſeſs alſo a *vis reproductiva*, or power of re-production. This latter is indeed a ſurpriſing faculty, deſtined not only to make reſtitution for the uniform removal of minute atoms by the neceſſary action of the animal economy, but alſo to repair the incidental loſs of larger parts (ſuffered in conſequence of external injuries, wounds, &c), by a perfect reſtoration of the ſubſtance of which the body has been thus forcibly deprived. That ſuch a power does unequivocally reſide in the bones, and a few other parts, of which we have juſt ſpoken, is with me too well aſcertained and ſubſtantiated to admit of a doubt.

§ 460.

But on the other hand, from a variety of obſervations and experiments which I have made both on man and other warm-blooded animals, this *power of reproduction* appears to reſide in ſcarcely any other ſolid parts of the body than *ſuch as are endowed with contractility alone, without poſſeſſing at the ſame time any of the other vital energies, ſuch as irritability, ſenſibility, or finally, ſpecific life.*

§ 461.

Of thoſe parts of the ſyſtem therefore (which poſſeſs the more exalted kinds of vital energy), the ſtaminal baſis appears to me to conſiſt of a *pe-*

rennial

rennial parenchyma, which is ſubject neither to genuine mutation nor decay, but only liable to certain *viciſſitudes* in point of bulk, that are produced in the following manner, namely, when the proceſs of nutrition is conducted with ſufficient activity and vigour, the cellular interſtices of the parenchyma, being uniformly filled with the rich and plaſtic lymph of the blood, are, of courſe, diſtended, and the parenchyma neceſſarily enlarged; but when, on the other hand, nutrition goes on leſs favourably, theſe ſame interſtices, being in a great meaſure deprived of this nutritious lymph, fall into a ſtate of collapſe, and the parts become conſequently diminiſhed in ſize.

§ 462.

With reſpect to this plaſtic lymph (of the dignity and importance of which we have ſpoken fully on a former occaſion), as it aſſumes with great facility the appearance and nature of genuine cellular membrane, ſo it appears to conſtitute generally the principal nutritious matter of the whole ſyſtem, and is conveyed to every part of the body by means of that infinitude of minute blood-veſſels, to which we have ſo often called the reader's attention.

§ 463.

During the time of the body's advancement in growth, it appears to poſſeſs certain peculiar or ſpecific powers, by the aid of which the lymph, being depoſited from the evaneſcent extremities of the ſanguiferous veſſels, into the ſurrounding cellular membrane, is duly arranged, and completely aſſimilated to each particular portion, and kind of parenchyma. To the head of theſe ſpecific powers, muſt we in part refer that particular law of affinity, by means of which the *partes ſimilares* of the ſyſtem attract and appropriate to themſelves, the homogeneous *elements* of the nutritious lymph, more eſpecially ſuch of them, as poſſeſs reciprocal and kindred propenſities; and to the ſame head may we alſo in part refer that *niſus formativus*, of which we will have occaſion to ſpeak more fully hereafter, and to which muſt be attributed, the juſt and ſpecific application of the rude, and hitherto formleſs, elementary matter, and its ſubſequent organiſation and arrangement into the form and figure of its peculiar deſtination.

§ 464.

It is, I preſume, from the joint co-operation of both the preceding powers, that we muſt principally derive the nutrition of thoſe parts of the body, which are not proximately ſupplied with any

blood

blood veſſels at all; ſuch as the nails, hairs, &c. and which are, notwithſtanding, generated at firſt, by a very powerful and truly infallible *niſus* or exertion, are afterwards advanced in magnitude, and regularly ſupported by nutriment throughout the whole of life, and, finally, if by accident removed, are again readily reſtored by the aſtoniſhing efforts of the *vis reproductiva.*

§ 465.

Although the preceding appears to be a general *breviate account* of the proceſs of nutrition, yet, on the other hand, it is evident that there exiſts, in different individuals, a great many varieties, with regard to the degrees and modes in which this function is diſcharged. Thus, for example, in proportion as a more lax or more cloſe *appoſition* and *union* of the nutritious matter are effected, the texture of the parts themſelves is rendered more denſe or delicate, and hence alſo ſeems to originate the difference between the ſpecific weight of human bodies; in which reſpect it is well known, not only that man differs from man, but even nation from nation: in teſtimony of this truth it may be ſufficient to adduce even a ſolitary example from among certain northern tribes, namely, the Jukutæ, the Buratæ, &c. people highly conſpicuous on account of the remarkable and truly ſingular levity of their bodies.

SECT.

SECT. XXXVII.

OF SECRETION.

§ 466.

BESIDES thofe juices deftined for the important procefs of nutrition, there are alfo in the animal fyftem other humours, of a very different order and character, which are extracted for various purpofes from the exuberant fountain of the blood. Thefe humours owe their exiftence to the procefs of fecretion, than which no function is lefs underftood by phyfiologifts; a *truth* mentioned as a fubject of juft regret, both by the immortal Haller and other preceding writers.

§ 467.

The fecreted humours, appear, in one point of view, to be fo extremely diverfified in their natures, and, in another, to bear fo ftriking an affinity to each other, that it is not poffible to reduce them to any, fave highly arbitrary, *claffes*. If, however, in treating of thefe humours, we found our divifions of them on the lefs and greater changes to which their elementary parts, (con-

tained

tained in the maſs of blood), are ſubjected in the ſecretory organs, they may be aptly enough enumerated in the following order.

Firſt, *the milk*, a fluid which we think proper to place at the head of our *cenſus* or enumeration, becauſe it may be conſidered, in ſome meaſure, as renovated chyle, and appears to be ſecreted, by the moſt ſimple proceſs, from the blood, to which the chyle had been recently united.

Secondly, the *aqueous fluids*; ſuch, for example, as the humours of the eye, and the tears: to the ſame head muſt we refer in like manner, the ſweat; and alſo, (if our opinion be not unfounded), that halitus which is contained generally in the interſtices of the cellular membrane, as well as in the cavities of the thorax and abdomen; this vapour appears to differ but very little either from the liquor of the pericardium, or from that ſubtle halitus by which the ventricles of the brain, and the pituitary ſinuſes of the cranium are preſerved in a ſtate of perpetual humidity.

Under the ſame head of aqueous fluids, it is likewiſe common to arrange the *urine*, although this is doubtleſs a liquid poſſeſſed of ſome ſingularly ſtriking and peculiar properties.

Of

Of a lefs compound nature are the *falivary* humours, which, in office, are fubfervient to maftication, to digeftion, and to chylification.

Thirdly, the *mucagenous fluids*, which inveft and lubricate the cavities of moft of the vifcera, that are deftined to the performance of the natural and genital functions, and alfo the internal furfaces of all the aerial avenues belonging to the fyftem, fuch as the *nares*, the *larynx*, and the *afpera arteria*.

Of a nature not widely different from the foregoing, is that portion of mucus which covers the internal fegment of the eyeball; as well as that which is fpread immediately beneath the epidermis.

Fourthly, the *adipofe humours* are, in particular, (befides the common fat itfelf), the medulla of the bones, and the fmegma or oily covering of the fkin, to which may be added the *cerumen aurium*, or waxlike fubftance invefting the external avenues of the ears.

Of a nature nearly related to the foregoing, is that unctuous fecretion, fo evident on the *glans penis* of the male, and about the *rima* or *os externum*, in the genital organs of the female.

Under

Under the ſame claſs may we alſo arrange that oily ſubſtance, with which the glands of Meibomius furniſh and anoint the eyelids.

Fifthly, what are commonly denominated by phyſiologiſts *gelatinous fluids*, examples of which we have in the *liquor amnii*, and *unguen* of the joints. Reſpecting the nature of theſe fluids, however, we are not yet poſſeſſed of a ſufficient number of well authenticated facts to give birth to unequivocal and ſatisfactory concluſions: a ſimilar obſervation may alſo be made, reſpecting that uninveſtigated and anonymous humour, which the female uterus diſcharges during the ardent glow of the venereal orgaſm.

We remain alſo as yet, in a ſtate of equal uncertainty reſpecting the nature of that fluid, which is lodged, during the firſt months after conception, between the chorion and amnios; of that which is contained in the umbilical *veſicula* or *pouch* of the embryo in its tendereſt ſtate; and alſo of that which is interpoſed between the three veſſels that conſtitute the umbilical cord.

The liquid encloſed in the *veſiculæ graffianæ* of the female ovary, and alſo the liquor of the proſtate gland, appear to be of a truly *ſerous* or *albuminous* nature.

Sixthly, the *male ſemen* appears to be a *humour* ſo remarkably ſingular in its nature, as not to admit of claſſification, nor even of compariſon, with any other.

And laſtly, with regard to the *bile*, there is equal room for the admiſſion of a ſimilar obſervation.

§ 468.

That the foregoing ſecreted humours, ſo extremely diverſified in their natures and habits, can neither be derived from the maſs of blood by the ſame individual proceſs, nor by organs of the ſame kind, is a propoſition too ſelf-evident to ſtand in need of, or indeed leave room for, any farther confirmation. Among theſe humours, there obviouſly exiſts this memorable variety, namely, that while ſome of them are ſecreted and conveyed from the blood through a *ſhorter route*, others again, are more elaborately prepared, by being carried onward through tubes of greater longitudinal extenſion.

§ 469.

Of all the modes of ſecretion, *that* muſt doubtleſs be conſidered as the moſt ſimple, in which the ſecreted humour appears to tranſude immediately through the coats of the arteries, by what phyſi-

ologiſts

ologifts call *diapedefis*. Inftances of this mode we have in the fecretion of the fat, and of the medulla refiding in the bones, &c.; and, finally, it appears to be by a modification of the fecretory procefs, not greatly diffimilar to the foregoing, that the gaftric liquor, the inteftinal liquor, &c. are prepared and difcharged into the cavities of their refpective vifcera.

§ 470.

The mechanifm of fecretion appears to be more compound, where that procefs is performed by means of *glands*, under which denomination we generally include even *follicles* and *cryptæ* themfelves; fuch, for example, as are eafily difcoverable in the fauces; and which phyfiologifts generally defignate by the name of *glandulæ fimpliffimæ*.

We beftow, with propriety, the denomination of fecreting glands, on thofe bodies which, (to diftinguifh them from the *conglobate*, belonging to the lymphatic fyftem), are called *conglomerate*; examples of which we have in the falivary glands, in the pancreas, in the lachrymal glands, and in the *mammæ*, or breafts of females. The foregoing glandular bodies are furnifhed with excretory ducts, which are compofed of tubes or canals running immediately from their larger lobes: thefe lobes,

lobes, on being submitted to farther examination, are found to be made up of smaller lobules, respecting the internal structure of which, there formerly existed very warm controversies in some of the most celebrated schools of medicine. Malpighi considered the small miliary globules, which may be readily demonstrated in the greater part of them, to be nothing else than genuine *acini* or *kernels*, containing, each one, a minute cavity in its centre. While Ruysch contended, on the other hand, that those hypothetical excavated kernels were nothing more than globular convolutions of extremely fine blood vessels; which latter opinion, is doubtless founded on by far the most unequivocal and substantial testimony, as we readily learn from well conducted anatomical investigations, more especially from successful injections, and the assistance of glasses.

§ 471.

Nor does this structure (if indeed we keep out of view the peculiar parenchyma of each particular viscus), differ much from, but appears rather to shed a considerable gleam of light on, the structure of certain other secreting viscera, particularly on that of the liver and kidneys, in which late experimenters have been able to demonstrate, with the utmost perspicuity, certain spherical bodies entirely similar to the globular convolutions of

Ruyfch, or the kernel-like fubftances of the celebrated Malpighi. For, in what is called the cortical portion of thofe vifcera, minute ramifications emerging from the fides of the fmall capillary arteries, become prefently convoluted, in fuch a manner, as to form little vafcular balls, which thus appear to hang by thofe ramifications of which they are compofed, like fo many fmall berries or grapes fupported by their footftalks. From thefe minute vafcular balls originate *firft*, that very fubtle and colourlefs order of veffels immediately deftined for the bufinefs of fecretion, (refpecting the origin of which, from the evanefcent terminations of arteries, we tranfiently fpoke on a former occafion, (§ 79. 81.); and *fecondly*, the incipient radicles of veins, into which the minute arteries are themfelves continuoufly reflected, and which conduct back to the venous trunks, the refidue of the blood now deprived of thofe elementary particles neceffary to conftitute the fluid recently fecreted.

§ 472.

Finally, certain other parts of the body, appropriated entirely to the bufinefs of fecretion, are diftinguifhed again by different and remarkably peculiar, fpecies of organization; thus the male teftes, for example, are wholly compofed of nothing elfe than clofe and mazy convolutions of very lengthy and numerous blood veffels, &c.

§ 473.

We come now to the confideration of the peculiar caufes, by the operation and efficacy of which *thofe* determinate and fpecific humours are fecreted in *thefe* correfponding determinate and fpecific organs: this is indeed the *Gordian knot*—this is by far the moft difficult point of difquifition in the whole doctrine of fecretion—that point which numerous doubts and difficulties yet inveft.

§ 474.

It appears indeed to be a truth afcertained and eftablifhed beyond the fainteft fhadow of a doubt, that the leading, and what may be called the proximate caufe of moft of the fecretions, muft be fought for in the internal ftructure of the fecreting organs themfelves: under this head we muft particularly confider, in the conglomerate glands and other fecreting vifcera, not only the peculiar diftribution and direction of the extreme blood-veffels, from which the humours are fecreted, but alfo the *parenchyma*, fo uniformly proper to each fecreting vifcus, that in many of them it can be inftantly known and diftinguifhed at firft fight from all other kinds or fpecies of flefh (§ 27).

§ 475.

It is alfo an opinion extremely probable (in fupport of which we have advanced, on former occafions,

occaſions, ſeveral arguments not eaſily refuted); that the ſecreting viſcera, beſides their peculiar parenchyma, poſſeſs alſo what we have taken the liberty to call a *vita propria*, i. e. a ſpecific or excluſive kind of vital energy, eſſentially different from what we denominated the three *common energies*, namely, contractility, irritability, and ſenſibility.

§ 476.

But further, if my views of the ſubject be in any meaſure juſt, the *abſorbent ſyſtem* appears to contribute alſo a very important part towards the promotion of the ſeveral ſecretions: thus, from each of the ſecreting viſcera certain appropriate branches of this ſyſtem abſorb and re-convey to the blood-veſſels larger or ſmaller portions of each of the ſeveral humours to which theſe viſcera give origin; the uniform conſequence of which is, that the blood becomes literally impregnated with the contagion of every humour ſecreted in the different parts of the body, e. g. with *bile* from the liver, with *ſemen* from the teſtes, &c.

Thus there appears to exiſt, in the ſyſtem deſtined for the buſineſs of ſecretion, a perpetual routine or circulation, ſo that the elementary parts of the humours already ſecreted being inceſſantly conveyed from the ſecreting organs

themſelves, are united afreſh to the maſs of blood, and on their ſubſequent return to their *parent organs*, in conjunction with the ſanguineous current, are again more eaſily attracted by the ſecreting veſſels, in conſequence of a peculiar law of affinity, and have alſo a power of drawing along with them thoſe parts of the blood that are moſt homogeneous in their nature, and for which they conſequently poſſeſs the higheſt degree of attraction.

§ 477.

To facilitate the ſecretion of *certain humours* of the body, adequate proviſion is made by the production of ſpecific qualities, in thoſe particular portions of the blood from which they are to be proximately derived: thus the bile is ſecreted from the blood of the *vena portarum*, a portion of fluid highly impregnated with *phlogiſton*, furniſhed in profuſion by the abdominal ſources, from which this blood immediately originates.

§ 478.

I paſs in ſilence over certain other co-operating aids, which act in ſubſervience to particular ſecretions, as *congeſtion* and *derivation*, ſo evidently efficacious in the ſecretion of milk, with other inſtances of a ſimilar nature.

§ 479.

Among the humours thus ſecreted by the organs which we have juſt deſcribed, and by the powers or cauſes juſt enumerated, it may be obſerved that the following difference afterwards exiſts, namely, while ſome of them drop immediately from their ſecreting organs into the places of their ultimate deſtination, in which they are to perform their ſpecific functions, others again are conveyed to appropriated receptacles, in which they are retained for ſome time, and thus farther matured previouſly to their final elimination from the ſyſtem: of this laſt deſcription is the milk which ſtagnates in the lactiferous ducts, the urine, the bile, and the ſemen maſculinum, which are ſubjected to retention in their veſicular receptacles, and finally, the *ſerum* contained in thoſe veſicles which were firſt diſcovered by de Graaff in the ovaria of the female.

SECT. XXXVIII.

OF THE URINE.

§ 480.

BESIDES the nutritious juices and the ſecreted humours deſtined for further ſervices in the animal economy (§ 4.), the blood furniſhes alſo materials for the formation of certain uſeleſs and ſuperfluous liquids, that are intended to be entirely eliminated from the ſyſtem, and are from thence vulgarly called *excrements of the ſecond digeſtion*. Theſe excrementitious liquids are of two kinds, one of which is exhaled by the proceſs of perſpiration, and has already engaged our particular attention; the other is the *urine*, a liquid ſecreted in thoſe glands denominated kidneys.

§ 481.

The kidneys are two viſcera ſituated behind the peritoneum, on each ſide of the ſpine, and in the upper part of the lumbar region: Although their figure is generally ſomewhat flatted, yet it is proper to obſerve, that both in this reſpect, and alſo in point of number, they are ſubject to more varieties than any other viſcus belonging to the human body: they hang by veſſels commonly called emulgents

emulgents (remarkably large in proportion to the magnitude of the parts on which they are diſtributed), and are cuſhioned round by fat of a ſebaceous conſiſtence (§ 38).

§ 482.

They are inveſted by a proper membrane, of an elegant vaſcular ſtructure: each one of them, eſpecially during the period of infancy, appears to be compoſed of about eight, or ſomewhat more, kidney-form lobes or ſubdiviſions; each of which conſiſts again (according to an opinion formerly entertained and taught by Ferrein), of about ſeventy or eighty fleſhy *radii*, which that phyſiologiſt called white pyramids.

§ 483.

If the kidney be diſſected or divided from its convex *dorſum* towards its concave *pelvis*, it exhibits in its compoſition two kinds of ſubſtance; one forming its circumference, and therefore denominated its *cortical*, the other conſtituting its centre, and hence called its *medullary*, portion.

Each portion abounds with ſanguiferous arteries and veins; beſides *which*, the external cortex is alſo furniſhed with an additional order of very minute colourleſs veſſels, deſtined to *ſecrete* the urine: while the medulla contains alſo veſſels of

 a ſimilar

a ſimilar deſcription, intended to *carry it onward* when ſecreted.

Thoſe ſecretory ducts originate, in the manner already deſcribed (§ 471.), from the ſmall globular convolutions of capillary arteries that are every where interſperſed throughout the cortex of the kidney: thoſe ducts conſtitute indeed by far the greater portion of the cortical ſubſtance of the kidney, and may be very eaſily diſtinguiſhed by their ſingular meanderings and intricate mazes, from the ſmall conducting tubes of Bellini, in which they finally terminate. Theſe *tubuli Belliniani* (as they are frequently termed) paſs by a direct route from the cortical, and enter the medullary ſubſtance, of which they conſtitute by far the greater part; and uniting afterwards by reiterated coalitions into a ſmall number of narrow trunks, finally perforate, by their extreme orifices, in a ſieve-like manner, the ſeveral *papillæ* contained in the renal pelvis.

§ 484.

The papillæ correſpond for the moſt part to the number of lobes, of which we already ſaid each kidney is compoſed. The urine that is ſecreted in the colourleſs veſſels of the cortex, and afterwards conducted through the tubuli Belliniani of the medulla, theſe papillæ diſcharge into their correſponding

correſponding *infundibula*, which form by their ſubſequent confluence the common *pelvis*.

§ 485.

The pelvis is continued into the *ureters*, which are membranous canals, exquiſitely ſenſible, and defended internally by a complete inveſtiture or lining of mucus; they are capable of extreme dilatation; in man they are here and there uneven in the width of their cavities, and are at length inſerted into the poſterior ſurface, not far from the neck of the urinary bladder. This inſertion is effected in ſuch a manner, that the ureters do not immediately perforate the parietes of the urinary cyſt, but deſcend a ſhort diſtance between its muſcular and nervous coats (which are here poſſeſſed of more than ordinary thickneſs), and open finally into the cavity of this organ by oblique orifices. By means of this ſtructure, adequate proviſion is made to prevent the urine, that has once entered the cavity of the bladder, from being forced to return again into the ureters by an inverted or retrograde motion.

§ 486.

In an adult ſubject, the urinary bladder is in general ſufficiently capacious to contain about two pounds of urine; its *fundus* or bottom, which in the fœtal ſtate terminates in the *urachus*, and alſo its

its poſterior ſide, are inveſted by the peritoneum; as to its remaining membranes or coats, they bear a general reſemblance to thoſe of the ſtomach, of which we have already ſpoken.

The *muſcular* coat conſiſts indeed of interrupted bands of fleſhy fibres, that ſurround the cyſt, forming at the ſame time various irregular decuſſations or interſections, which are different in different ſubjects: this muſcular coat phyſiologiſts denominated *detruſor urinæ*, while they deſignate by the name of *ſphincter veſicæ*, thoſe orbicular fibres that partially ſurround the neck of the bladder, though they are very inconſtant and irregular, both with reſpect to their figure and origin.

The *nervous coat* beſtows on this membranous viſcus alſo the principal part of its ſtrength and firmneſs.

Finally, the *internal* coat, which is conſidered by phyſiologiſts as à proceſs or continuation of the epidermis, is defended by a complete covering of mucus, eſpecially round the neck of the bladder.

§ 487.

Beſides thoſe public and well known routes of the urine, of which we have already ſpoken, it appears probable from ſeveral phenomena, that there

there exiſt alſo certain ſecret avenues, which lead immediately from the inteſtines to the uropoietic organs. For the ſpeedy diſcharge of certain drinks from the urinary emunctory, ſo frequently imbued with the odour, tinctured with the colour, and characterized by other ſpecific qualities of the aliments recently taken in, will ſcarcely admit the belief, that theſe liquids had performed, in ſo ſhort a time, the cuſtomary long and circuitous route through the thoracic duct and ſanguiferous ſyſtem: to the foregoing circumſtance we may add an account we have read, of the urine having been found covered with *oil*, that entered into the compoſition of an enema, which had been previouſly and recently thrown into the inteſtinum rectum. It is, on the other hand, a circumſtance well known to phyſiologiſts of the preſent day, that very ſtriking and numerous anaſtomoſes occur between the lymphatic veſſels of the inteſtines, and thoſe of the kidneys. Laſtly, it is now unequivocally aſcertained and confirmed by live diſſections, that if both ureters of a dog be tightly encloſed in ligatures, and his *bladder* perfectly evacuated of its contents, this latter organ will, notwithſtanding, in the term of three hours afterwards, contain a certain quantity of urine; while at the ſame time the uſual avenues of this fluid, namely, the ureters, are completely obſtructed, as is evident from this circumſtance, that above the

ligatures

ligatures these tubes suffer vast distention from the accumulated urine.

§ 488.

But through whatever avenues the urine has been conveyed to the bladder, its gradual accumulation in that organ excites an uneasy sensation, which becoming urgent and troublesome (§ 331.) potently solicits its final elimination, through an emissary or sewer destined for that particular purpose, namely, the *urethra*. This excretory canal is subjected to a variety in its conformation, founded on the diversity of the sexes, of which we will speak more amply when treating professedly of the sexual functions.

§ 489.

In order to evacuate the bladder, it is necessary to overcome the contraction of its sphincter, by the exertion of its own *detrusor* (of which we formerly spoke) (§ 486.), aided by the co-operation of the abdominal muscles, and those subservient to the process of respiration; to which, in males of the human species, we may add, lastly, the action of the *musculi acceleratores*, which forcibly ejaculate, *per saltum*, as it were, even the residuary drops of urine that may be occasionally lodged in the bulb of the urethra.

§ 490.

As to the *nature* of the *urine* itſelf, it is ſubject indeed, to an infinitude of varieties generated by the circumſtances of age, and ſeaſon, but, above all, by the longer or ſhorter term of time, ſubſequent to the previous uſe of food and drink, the diſcharge of this fluid occurs; to which may be alſo added, the quality of the aliment previouſly uſed, &c. In general, however, when we examine the urine which is diſcharged by a healthy human adult, immediately after ſound and tranquil ſleep, we diſcover it to be a watery liquid, of a nidorous ſmell, and citron colour, containing in its aqueous medium, (as in a common vehicle) various elementary ſubſtances, eſpecially *earthy* and *ſaline*, which bear different proportions to each other in different individuals, and even in the ſame individual at different times and under the influence of different circumſtances. Of the terrene elements the moſt abundant is, in general, calcareous earth, which is not unfrequently found in the urinary paſſages under the form of *calculi*, but which is, notwithſtanding, extremely variable and inconſtant in its quantity. Of all the ſaline matters, that moſt worthy of being mentioned, is the *eſſential* and *native ſalt* of urine—called alſo, *microcoſmic ſalt*, *fuſible ſalt*, &c. This ſaline ſubſtance contains, in a greater proportion than any other

other part of the human body, the celebrated phosphoric acid chemically espoused to the volatile alkali.

SECT. XXXIX.

OF THE DISCRIMINATION OF THE SEXES IN GENERAL.

§ 491.

THOSE functions of the human body, in the consideration of which we have been hitherto engaged, are indeed possessed, and exercised in common, by the individuals of each sex: with respect to the mode, however, in which some of them are performed, there occur between the two sexes no inconsiderable degrees of difference. Of this difference, it may be proper briefly to enumerate the leading points, previously to our entrance on the consideration of what are denominated the *sexual functions*.

§ 492.

To speak, then, in general terms, each sex possesses and exhibits its *own* peculiar *habit*, which differs considerably from *that* of the other. In the

the human ſubject after birth, this difference of habit is diſtinctly obſervable; but during the tender fœtal ſtate, is ſcarcely to be diſtinguiſhed, unleſs by more cloſe and pointed attention; neither indeed, in this ſtate, can the external organs of generation themſelves be diſcriminated, on a tranſient and ſuperficial view, owing to the extraordinary magnitude and prominency of the female clitoris, and the very diminutive ſize of the male ſcrotum.

§ 493.

During the period of infancy this difference of the general habit, depending on the diverſity of ſex, makes only a ſlight impreſſion on the obſerver; but becomes gradually more and more obvious and ſtriking till the full completion of the years of *puberty*, at which period, the general conformation of the female body, its tenderneſs, its ſoftneſs, and the uſual inferiority of its ſtature, contraſted with the athletic and robuſt body of the male, exhibit this general *habitual* difference in the moſt ſtriking point of view.

§ 494.

Similar to the difference that occurs between the *external habits* of body, that characteriſe the two ſexes, is that which is obſervable in the bones

them-

themſelves. Theſe ſolid portions (all other circumſtances being alike) are evidently much more ſmooth and round in females than in males; the cylindrical bones, in particular, are more ſlender and delicate, and the plane ones more attenuated or thin, in the former, than in the latter ſex; not to mention the peculiar diverſities of certain remarkable bones, particularly thoſe of the thorax and pelvis, with the clavicles, the femora, &c.

§ 495.

With reſpect to the ſoft parts of the body, we may obſerve in general, that in females, the cellular membrane is more lax, more pliable, and conſequently more readily dilatable in the ſtate of pregnancy: while the ſkin is more tender, fair and beautiful, in conſequence of the immediate ſubſtratum of fat.

The hair of the head is generally of a greater length in *females* than in *males*, while at the ſame time, certain other parts of the body which in the latter are rough and hairy, are in the former either perfectly ſmooth, as the chin and breaſt; leſs hairy, as the perineum; or planted with only a very tender and ſoft down, as the arms and legs.

§ 496.

When ſpeaking of the diverſities of particular functions, we muſt not ſilently pretermit the pulſe, which (other circumſtances being alike) is more frequent in females than in males, (§ 109). In the former, the *thorax* is ſubjected to a greater degree of motion, (eſpecially at its ſuperior part,) than in the latter; the os hyoides is much ſmaller, the larynx is leſs capacious, and hence the voice more ſhrill.

§ 497.

With regard to the animal functions, it is neceſſary to obſerve in general, that in females the mobility of the nervous ſyſtem is much greater than in males, the irritability is more exquiſite; and the propenſity to commotions of the mind, more prompt and ſpontaneous.

§ 498.

As to the natural functions, the appetite for food is weaker in the female, than in the male ſex; while, on the other hand, the increaſe of the body is more rapid in the former, and the ſtate of puberty and mature growth attained at an earlier period.

§ 499.

But by far the greateſt and moſt important diſtinction of the ſexes is derived from the genital functions themſelves, the male being furniſhed with a power of *fœcundation*, and the female with that of *conception*. A farther inveſtigation of theſe powers ſhall engage the greater part of our attention, throughout the remaining pages of this work.

SECT. XL.

OF THE GENITAL FUNCTION OF THE MALE SEX.

§ 500.

THE genital liquor of the male is prepared by the *teſtes*, two bodies ſuſpended in the ſcrotum by their *ſpermatic cords*, and (beſides the lymphatic veins with which they abound in profuſion), compoſed chiefly of *three* kinds of veſſels.

Theſe are *firſt*, the *ſpermatic artery*, which in proportion to its ſlender diameter is ſaid to be the longeſt of all the arteries belonging to the human body:

body: it in general conveys the blood immediately from the abdominal portion of the aorta itself, to the body of the testis.

Secondly, the *ductus deferens*, which carries to the *visiculæ seminales*, the semen when once secreted from the arterial blood.

And, lastly, what is commonly denominated the *pampiniform plexus of veins*, the function of which is to receive and convey to the cava or emulgent vein, the blood that remains after the process of secretion is accomplished.

§ 501.

The testes are not, from the time of their earliest formation, suspended in the scrotum, as represented in the above description: thus in the male fœtus, while yet in a very tender and immature state, those glandular bodies occupy indeed a very different situation, the reason and successive changes of which were first accurately investigated and detailed by Haller, at Gottengen in the year 1749, but were afterwards explained by other writers on principles so different from each other, as to have given rise to various controversies of some weight and importance. Of the situation and changes of the testes in the fœtal state, I am prepared to lay before the reader a brief, though

comprehenſive account,—the ſpontaneous reſult of numerous obſervations made on nature herſelf, during a remarkable ſeries of diſſections of male embryo's, in which I engaged for the expreſs purpoſe of ſhedding light on this ſubject ſo intereſting to phyſiologiſts.

§ 502.

On opening the lower abdominal region of an immature fœtus, we diſcover in each groin, near what is called the ring of the oblique muſcles, a very narrow orifice in the membrane denominated peritoneum; this orifice is the threſhold to a ſtrait avenue or alley, as it were, that leads through the abdominal ring itſelf, and terminates afterwards in a peculiar bullous or bubble like ſack: this ſack extends without the abdominal cavity, looks towards the ſcrotum, is interwoven with cellular fibres, and deſtined for the future reception of the teſtis.

§ 503.

At the very poſterior margin of this ſmall abdominal orifice, the peritoneum ſends off another proceſs, which mounts upwards, and in the tender fœtus repreſents, in the greater part of its courſe, a longitudinal fold: from the baſis of this proceſs a ſlender cylinder, or rather inverted cone aſcends, and forms at its ſummit, which regards the

the inferior margin of the kidney, a ſmall bliſter or ſack-like termination; in this ſack the teſtis and epididymis are encloſed; ſo as to reſemble, at firſt ſight, a ſmall berry reſting on its footſtalk, and appear, at the ſame time, to hang looſely into the abdominal cavity ſomewhat like the liver or ſpleen (§ 404).

§ 504.

The veſſels which are afterwards to conſtitute the ſpermatic cord, are, at this very early period, ſeen running behind the extremely tender and pellucid peritoneum, ſo that the ſpermatic artery and vein run in a deſcending direction along the ſides of the ſpine, while the *vas deferens* bending ſomewhat inwardly towards the neck of the urinary bladder, ſtretches along the looſe cellular membrane, which is ſituated behind the peritoneum, and both enter the body of the teſtis in that peritoneal *plica* or fold of which we have already ſpoken.

§ 505.

From about the middle ſtage of pregnancy, the teſtes begin to ſink downward by degrees, ſo as gradually to approach the narrow orifice of the peritoneum, which has been already mentioned. At the ſame time, the foregoing peritoneal fold, with its cylindrical attachment, are wrapped up

by degrees, till the teſtis finally reſts on the very mouth of the preceding canal.

§ 506.

When in the fœtus, now advanced to a higher ſtage of maturity, the teſtis is fully prepared for a final deſcent, the orifice, hitherto ſo contracted or narrow, ſuffers ſuch a remarkable dilatation, that the teſtis is at full liberty to enter with facility the opening that leads out of the abdomen as well as the ring by which this opening is ſurrounded, to paſs onward through the whole length of the canal, and thus plunge headlong, as it were, into the bliſter-like ſac of which we have already ſpoken. The teſtis having finally accompliſhed its deſcent, the peritoneal opening is ſoon after cloſed in the moſt complete manner, and even ſubjected in a ſhort time to a perfect adheſion of its ſides, ſo that in the ſtage of *infancy*, ſcarcely a wreck of it is left, to point the enquirer to the place of its former exiſtence.

§ 507.

The more gradual and ſlow the movement of the teſtis (while yet in the abdominal cavity) towards the orifice of its egreſſion, the more ſudden and inſtantaneous appears to be its act of tranſition through the abdominal ring. For in the diſſections of mature fœtuſes, it is by no means

uncom-

uncommon to diſcover the teſtis either as yet incumbent on the peritoneal opening, or elſe ſtationary in the groin, after having recently paſſed the abdominal ring: but once only was I ſo fortunate as to have an opportunity of obſerving the right teſticle of a twin-fœtus (of which a complete drawing has been given), at the very moment of its paſſage through the abdominal ring: the gland appeared to have been very tightly embraced and ſtrangled, as it were, by the ſurrounding parts, and was apparently in complete readineſs to emerge from the abdomen into its deſtined ſack; a tranſition already accompliſhed by the left teſticle, that had juſt eſcaped from the ring, the orifice of which had again reſumed its former impervious ſtate.

§ 508.

This remarkable deſcent of the teſtes along the groins, does not appear to be excluſively confined to any particular period of time: it occurs for the moſt part, however, about the laſt month of pregnancy: although theſe glandular bodies are not unfrequently found either in the abdominal cavity itſelf, or in the ſuperior part of their inguinal route, even in infants after birth. For the teſticle, after its entire eſcape from the abdomen, has ſtill a further ſtage of its journey to perform, namely, its final deſcent along the groin into the

ſcrotum, in company with the ſmall ſac by which it is enveloped.

§ 509.

That the foregoing is indeed a true account of the progreſſive movement of the teſtes in their deſcent from the abdomen into the ſcrotum, I have had ſufficient opportunities of aſcertaining from repeated obſervation. To develope the *cauſes* and *energies* by which this aſtoniſhing deſcent is accompliſhed, appears to be indeed attended with difficulties of the utmoſt magnitude. For I am daily more and more convinced, that neither of thoſe powers to which this deſcent has been hitherto aſcribed (ſuch, for example, as the action of the cremaſter muſcle, the action of the diaphragm, or the contractility alone of that cellular and tendinous intertexture, which adheres to the proceſſes of the peritoneum, and is uſually denominated *gubernaculum* Hunterii, &c.), is ſufficient to explain a movement of ſuch extreme ſingularity, eſpecially that part of it relating to the immediate tranſition of the teſtis through the narrow abdominal ring, to which the reader's attention has been ſo frequently ſolicited: while I am impreſſed, on the other hand, by a thorough conviction, that this whole proceſs exhibits the moſt unequivocal aud ſtriking example of what we have denominated *ſpecific life*, without the peculiar operation

tion and aid of which, it is ſcarcely poſſible to ſolve the ſeveral phenomena of a tranſition ſo extremely ſingular in its nature, and ſo widely diſſimilar to all other movements and functions that occur in the whole animal economy.

§ 510.

The involucra by which the teſtes are inveſted, after their final completion of the foregoing route, may be aptly enough divided into *common* and *proper*.

The only involucrum common to both theſe glandular bodies is the *ſcrotum*. This is a ſac, conſiſting of a tender portion of cutis expanded over a thin ſubſtratum of fat, and poſſeſſing a peculiarity that does not reſide in any other part of the common integuments of the body, namely, a power of changing, in a very remarkable degree, its uſual habit and appearance: thus, it ſometimes depends looſe and flaccid, and again (eſpecially under the impreſſion of the venereal œſtrum, or in caſe of expoſure to cold), becomes conſtricted and rigid, as it were, and is then particularly marked by furrows and diverſified rugoſities.

§ 511.

Of thoſe involucra which are proper to each teſtis, that placed immediately beneath and within the

the ſcrotum, is called the *tunica dartos* : this coat poſſeſſes a very peculiar and vivid *contractility*, by which Winſlow, Haller, and other celebrated characters have been ſo far deceived, as to beſtow on it the nature and energy of a muſcle.

§ 512.

This is ſucceeded (after a voluminous and ſoft ſtratum of cellular membrane), by three ſeparate *vaginal coverings*, which were firſt accurately traced and diſtinguiſhed by the ingenious and indefatigable Neubauer.

Of theſe vaginal coats, the exterior is *common* to the teſticle and ſpermatic cord, and has the cremaſter muſcle attached to it by ſeparate bundles of fibres.

But the two interior are *proper*, one to the ſpermatic cord, and the other to the teſtis itſelf; of theſe the latter adheres, for the moſt part, by its fundus to the common tunic, while its internal ſurface is moiſtened by a lubricant fluid, ſomewhat after the manner of the pericardium.

§ 513.

The *origin* of thoſe vaginal tunics which has given riſe to ſuch a variety of controverſies among phyſiologiſts, can, (if I be not greatly deceived), be

be without difficulty afcertained, from what has been already faid, when treating of the defcent of the teftes.

Thus, the *tunica communis*, for example, originates from the defcending (§ 502.) blifter-like fac or procefs of the peritoneum.

The *propria teftis*, from that production of the peritoneum, which mounting upward in the form of a cylinder (§ 503.), invefts the teftis itfelf from its earlieft formation.

And, finally, the *propria funiculi*, from that fold of the peritoneum, of which we have already fpoken, and the fhort cylinder in which it terminates previoufly to its embracing the teftis itfelf.

§ 514.

Immediately to the teftis itfelf the *tunica albuginea* is very clofely attached, fomewhat after the manner of a cortical covering. From this tunic, blood-veffels pafs into the *pulp* or body of the tefticle, which confifts indeed entirely of innumerable veffels, about a fpan in length, wound up into fmall conglomerate lobules: thefe veffels, of which the fubftance of the tefticle is compofed, are both fanguiferous and fecreting, the latter of

which

which conduct the ſemen, when prepared, through the vaſcular net-work of Haller, and the *vaſa defferentia* of Graaf, into the beginnings of thoſe cones that form the epididymis.

§ 515.

That body which ranges along the ſide of the teſtis, namely, the *epididymis*, conſiſts indeed of a ſingle veſſel, about thirty feet in length, which at one end (that for inſtance denominated its head), is diſtinguiſhed into about twenty ſmall rolls or cones, and at its other (inferior) extremity, called therefore its tail, increaſes gradually in thickneſs, and thus forms by its continuation the *vas deferens*.

§ 516.

The two *vaſa deferentia* aſcending towards the neck of the urinary bladder, and forming a junction beneath, or near to, the proſtate gland, are from hence bent backward, and expanded into the *veſiculæ ſeminales;* in ſuch a manner, however, that theſe veſiculæ, and the vaſa deferentia themſelves, open by two common orifices into the urethra, juſt behind the *caput gallinaginis*.

§ 517.

Finally, the *veſiculæ ſeminales* themſelves, are attached to the poſterior ſurface of the urinary cyſt,

cyſt, near to the inferior extremity, or neck, of that organ: they are imbedded in a profuſe quantity of fat, and from their diverſified flexuoſities and numerous blind *appendiculæ* that ſhoot oft ſomewhat in the form of ramifications, reſemble, in their general appearance, two ſmall inteſtines.

Theſe veſiculæ conſiſt of two coats, almoſt of the ſame kind with thoſe that enter, as formerly mentioned, into the compoſition of the gall bladder; thus, the firſt or external coat is more robuſt, and ſimilar in its nature to ſuch as are commonly denominated *nervous;* while the ſecond or internal abounds with minute cells and pits, and is every where divided, by means of projecting eminences, into minute purſe-like cavities, perfectly ſimilar to thoſe that are ſo conſpicuous about the neck of the gall-bladder.

§ 518.

In thoſe organs and veſſels hitherto enumerated and deſcribed, there is, even from the earlieſt years of puberty, a certain fluid ſecreted ſlowly, and retained in ſmall quantity, namely, the *ſemen maſculinum;* a liquor extremely ſingular in its nature, and of the utmoſt dignity and importance in the animal economy: it exhibits to the eye a milky colour, emits an odour entirely peculiar, poſſeſſes a mucoid viſcoſity, and is of ſuch

ſuch remarkable ſpecific gravity, as to ſurpaſs, in this reſpect, all other ſecreted humours belonging to the animal body.

§ 519.

A peculiarity of this fluid, which muſt not be paſſed over in ſilence, is, (as was firſt obſerved by Lud. Ham at Dantzic, in the year 1677), that it is peopled by a countleſs multitude of microſcopic animalculæ, belonging to the ſame order with thoſe called *infuſoria*, and poſſeſſing different figures, as they appear in the ſeminal fluids of different animals. In man (and alſo in the male aſs) the *ſeminal animalcules* exhibit oval figures, furniſhed with tails of extreme minuteneſs: theſe animalcules are ſaid not to be found in any, ſave ſound and prolific ſemen, ſo that they appear to conſtitute a certain *adventitious* criterion of the fertilizing maturity of this important fluid: we have called the criterion derived from theſe animalcules *adventitious*, and preſume it is ſcarcely neceſſary, at this enlightened period, to repeat, that they ſhould not be accounted the reſervoirs of the fecundating principle, much leſs ſhould they be conſidered as the germs of future *homunculi*, ſince ſo many, and ſuch weighty arguments and obſervations have been lately advanced in ſupport of a different doctrine.

§ 520.

§ 520.

This genital liquid being gradually collected in the veſiculæ, which we have already deſcribed, is there retained till a future act of excretion. By ſuch retention it ſuffers changes very nearly reſembling thoſe to which the bile is ſubjected in conſequence of a ſtate of ſtagnancy in its cyſtic reſervoir; thus, being gradually robbed of its aqueous portion, it is more and more inſpiſſated and approximated, as it were, towards a ſtate of concentration.

§ 521.

For as the teſtes generally, together with the cords by which they are ſuſpended, abound with an aſtoniſhing aſſemblage of lymphatic veſſels, which ſerve to re-convey from thence to the blood a portion of fluid, impregnated with the ſpermatic contagion, and by this means aid and facilitate the further ſecretion of ſemen, on the principle, and in the manner formerly laid down (§ 476.), ſo are the *veſiculæ ſeminales* themſelves alſo provided with veſſels of the ſame kind, which by abſorbing the ſubtle, though inert water, render the reſidue of the ſeminal fluid more active and efficacious.

§ 522.

§ 522.

On this ſubject I doubt much whether or not, in a healthy man, any genuine ſemen be ever abſorbed from the veſiculæ ſeminales:—more ſtill, whether or not, as is ſometimes alleged, ſemen thus abſorbed could be carried immediately into the neighbouring ſanguiferous veins:—but moſt of all, whether or not ſuch a ſeminal abſorption (admitting its real exiſtence) could poſſibly act as an antidote againſt exceſſive venereal propenſities, ſince it appears evidently, on the other hand, that this ſame abſorption would neceſſarily operate as an exciting cauſe of unbridled and almoſt infuriate luſt: in queſt of teſtimony to eſtabliſh the truth of this latter propoſition, we need only attend to the *phenomena* of ſuch animals as experience the venereal propenſity only at ſtated ſeaſons of the year, and compare them with the conſtitution of thoſe that have been reduced to the ſtate of caſtration.

§ 523.

To me indeed it appears probable, that, for the purpoſe of moderating libidinous deſires, man is endowed with a far different prerogative (not conferred on any other ſpecies of animals with which we are hitherto acquainted), namely, that of *nocturnal pollutions*: theſe *evacuations* I therefore conſider among the natural excretions of man

—*evacuations* by which (as they occur at longer or ſhorter intervals, according to the varieties of temperament and conſtitution), he is relieved from a troubleſome and otherwiſe urgent impreſſion produced by an abundant accumulation of ſemen.

§ 524.

It muſt be obſerved, however, that the ſemen maſculinum is never excreted in a ſtate of entire purity, but is always blended with more or leſs of what is uſually denominated *liquor proſtatæ* (i. e. the liquor of the proſtate). With regard to the external habit and appearance of this laſt mentioned liquid, it bears a very ſtriking ſimilitude to the albumen or white of eggs. This peculiar liquor derives its name from its immediate *birth-place* or ſource, which is a body of conſiderable magnitude, and of a ſingular and very compact parenchymatous texture, ſituated between the *veſiculæ ſeminales* and the bulb of the urethra, and is uſually deſignated by the name of *glandula proſtata*. The excretory avenues of this liquor have not yet been ſatisfactorily inveſtigated and aſcertained, unleſs (as appears probable) they communicate with the duct of the *caruncula ſeminalis*, the orifice of which opens into the urethra between the two mouths of the avenues leading from thoſe minute veſicles deſtined for the recep-

tion and temporary retention of the fertilizing ſemen, (§ 516).

525.

The *urethra* in man is deſtined as a common conduit or emiſſary duct, to three different kinds of fluids, namely, the urine, the ſemen, and the liquor of the proſtate gland. It is lined internally with a mucus which originates from an immenſe number of ſinuſes, that are every where diſperſed throughout its canal. It is ſurrounded by a ſubſtance of a ſpongy texture, to which are ſubjoined two other bodies, ſimilar in ſtructure but far ſuperior in ſize, (called *corpora cavernoſa*), that conſtitute the principal part of the *male penis;* an organ which is terminated anteriorly by the *glans*, and wholly inveſted by a very tender and pliable portion of ſkin entirely deſtitute of all appearance of fat. This ſkin forms the prepuce by its attachment round the *corona*, or circular baſe of the *glans*, and plays over this body with a free motion, ſomewhat like the palpebræ over the ball of the eye. The interior duplicature of the prepuce, having aſſumed a different appearance, is reflected over the glans itſelf, (ſomewhat like the adnata over the eye) and is furniſhed around the corona, with an immenſe number of the ſmall glands of *Littrius*, (analogous to the Meibomian glands of the

the palpebræ) that give birth to a matter of an unctuous but very ſingular nature.

§ 526.

The male penis, thus organiſed and conſtructed agreeably to the preceding deſcription, poſſeſſes a faculty of erection, *i. e.* in conſequence of an encreaſed *congeſtion* and impetuous *effuſion* (for congeſtion alone will not explain the phenomenon) of blood into the *corpora cavernoſa*; the penis ſwells, becomes rigid, and changes its former poſition, but ſuffers again a detumeſcence and collapſe by a reabſorption of the ſuperfluous portion of this diſtending fluid.

§ 527.

When the penis reſumes its flaccid condition, it ſuffers a ſingularly circuitous flexion, at the place where it originates from the neck of the bladder. In this ſtate it is, indeed, extremely well calculated for the excretion of real urine, but quite unqualified for the emiſſion of ſemen, as the beginning of the urethra forms now a more acute angle with the ſmall orifices of the veſiculæ ſeminales.

§ 528.

When a gradual intumeſcence of the penis commences, there occurs firſt an effuſion of the *liquor*

 furniſhed

furniſhed by the proſtate gland, which is oftentimes eliminated unmixed, but ſcarely ever along with the urine. Of this liquor the primary deſtination is, to be ejected, in conjunction with the *ſeminal fluid* itſelf; either, that it may, by its albuminoid lubricity, qualify the ſluggiſh tenacity of the latter fluid, and thus facilitate and promote its ejection; or that it may itſelf contribute, in a certain degree, towards the proceſs of generation.

§ 529.

The emiſſion itſelf of the male ſemen is *excited* as well by the immediate impreſſion ariſing from an abundant accumulation of this fluid in its appropriated receptacles, as by the genuine *ſexual inſtinct;* it is *accompliſhed*, firſt, by a very ſtrong *erection* of the penis, which, while it obſtructs the paſſage of the urine, paves as it were, on the other hand, a more direct and ready way for the tranſition of the ſemen; to which we may ſubjoin, as co-operating cauſes, a certain *ſpaſmodic contraction* of the veſiculæ ſeminales, a convulſive action of the *levator ani*, and *acceleratores urinæ*, and finally, a general *ſuccuſſion*, of the whole nervous ſyſtem, gentle indeed in degree, and tranſient in exiſtence, but yet of an epileptic nature, and conſiderably depreſſing, in its effects, on the energies of the ſyſtem.

SECT.

SECT. XLI.

OF THE GENITAL FUNCTION OF THE FEMALE SEX IN GENERAL.

§ 530.

As the male organs of generation are naturally calculated to *give*, ſo are the female to *receive*, and in the two ſexes theſe organs are, in a general point of view, widely different from each other. It muſt be obſerved, however, that in the general ſtructure of certain parts, theſe two kinds of organs exhibit no ſmall degree of reciprocal ſimilitude. Thus beneath the pubes (the ſtructure of which has been already a ſubject of tranſient attention (§ 36.) the *clitoris* which lies concealed in the ſuperior commiſſure of the labia, reſembles the male penis in more reſpects than one, but is not furniſhed with a urethra, is therefore imperforate, and, (when not of a preternatural proportion,) is remarkably ſmall. It is ſaid, however, that this organ preſerves, occaſionally, even in adults, the ſame proportional ſize, which, as formerly obſerved, is ſo extremely conſpicuous in the clitoris of the female embryo, (§ 492.) Hence appears, in all probability, to have originated moſt of thoſe obſcene and fabulous

ſtories, reſpecting the exiſtence of *hermaphrodites.* This organ conſiſts alſo, like the male penis, of *corpora cavernoſa*, like it, is capable of erection, like it, is inveſted by a prepuce, and furniſhes, finally, an unctuous matter not diſſimilar to that of Littrius, (§ 525).

§ 531.

From the clitoris deſcend the *nymphæ*, acquiring, alſo, occaſionally, an enormous and preternatural magnitude, (which exceſs has, in like manner, not unfrequently given riſe to extraordinary and fabulous reports): they poſſeſs, in common with the clitoris the moſt exquiſite degree of ſenſibility; and appear to give direction to the ſtream of urine when diſcharged, as the *orifice* of the *urethra*, (a tube extremely ſhort in the female ſex, and, in the moſt highly finiſhed and perfect examples, ciliated or fringed in a very ſingular manner), lies hid, as it were, in a foſſa formed by their two baſes.

§ 532.

Beneath this orifice is ſituated the *opening* of the *vagina* itſelf, environed by *cryptæ* of various kinds, ſuch, for example, as the *urethral lacunæ* of Graaf, and the mouths of what are improperly and even abſurdly termed, the proſtate glands of Caſp. Bartholin, &c. with the unguen-like mucus of

of which, theſe obſcene parts are moiſtened and lubricated.

§ 533.

Over the very threſhold or entrance of the vagina is expanded a weblike production denominated the *hymen*. This is a membrane, the exiſtence of which in an unlacerated condition, is conſidered as a ſure badge of ſpotleſs virginity—a membrane beſtowed excluſively on the female of the human ſpecies, and of which no phyſical deſtination has been yet unequivocally aſcertained.

The fringes or reſidual fragments of this membrane, after laceration, are gradually converted into what are denominated *carunculæ myrtiformes*, bodies quite indefinite in point of number.

§ 534.

From the immediate ſeat of theſe minute myrtiform bodies aſcends, between the urinary cyſt and inteſtinum rectum, the *vagina*, a tube compoſed of a cellular parenchyma, interſperſed with an infinitude of ſmall blood-veſſels. At its inferior extremity the vagina is encircled by a muſcle denominated *conſtrictor cunni;* more internally it is lined by a very ſoft and delicate coat, which is characteriſed by two extremely elegant *columns* of *rugæ* or wrinkles, namely, the anterior and poſte-

rior; from theſe columns a fine mucus is conſtantly diſcharged, deſtined to lubricate the cavity of this highly important canal.

§ 535.

The vagina, at its upper and interior end, receives and embraces, finally, the *uterus*, an organ attached on each ſide to, and thus ſuſpended by, the *ligamenta lata*.

The cylindrical neck of this organ being thus embraced, as it were, by the vagina, is perforated by a narrow canal, which, like that of the vagina, is impreſſed by a ſingular apparatus or arrangement of rugoſities, deſignated by the name of *arbor vitæ*: of this canal the two extreme orifices, more eſpecially the ſuperior or internal, are overſpread, for the moſt part, with a quantity of tenacious mucus.

§ 536.

The ſubſtance of the uterus is altogether ſingular in its nature, conſiſting of a peculiar parenchyma, very denſe and compact, and interwoven with an infinitude of blood-veſſels (running in ſerpentine mazes of aſtoniſhing intricacy) of which, the veins are wholly deſtitute of valves. This organ is doubtleſs furniſhed, in like manner, with an apparatus of lymphatic veſſels: it abounds with

with a countlefs number of nerves, through the medium of which, it preferves fuch an aftonifhing fympathy with the other parts of the fyftem.

§ 537.

Externally the uterus is invefted by the peritoneum, while its minute internal cavity is lined, efpecially at its *fundus*, by a very foft and tender membrane, of a fpongy texture, which, as fome phyfiologifts allege, confifts of colourlefs veffels, while others pronounce it to be compofed of lymphatic abforbents.

§ 538.

With regard to the mufcular texture attributed to this organ by fome phyfiologifts, and ftrenuoufly denied again by others, I muft take the liberty of obferving, that notwithftanding the number of uteri which I have examined with the utmoft care and attention, both in an impregnated and an unimpregnated ftate, (in each of which I have had repeated opportunities of examining this organ, not only in a prepared condition, but alfo in fubjects recently dead), I have never yet been able to detect, in them, any portion that exhibited obvious and unequivocal figns of mufcularity. On the other hand, I am daily more and more perfuaded, that the uterus, poffeffing no mufcular fibres, is deftitute alfo of true irritability (§ 307), and

and owes entirely to a *vita propria*, or ſpecific life (§ 47.), all its peculiar motions and functions, which cannot, indeed, with the ſmalleſt ſemblance of propriety, be derived from any of thoſe energies that are common to what we formerly termed the *partes ſimilares*, or ſimilar parts of the body (§ 43, 46). So very ſingular and unaccountable did the motions and functions of the uterus appear to the phyſicians and philoſophers of ancient times, that they were led to conſider this organ as a ſmaller animal contained within a larger.

§ 539.

From the angles on each ſide of the *lacunar*, or *fundus uteri*, ariſe what are called the *Fallopian tubes*. Theſe are two very narrow and tortuous canals, that run in the ſuperior duplicature of the *ligamenta lata*: they are ſimilar in texture to the vagina itſelf, except, that being internally deſtitute of valves, they are lined with a kind of ſpongy fleſh, of a very ſoft and tender conſiſtence.

§ 540.

The extreme orifices of theſe tubes, that regard the abdominal cavity, beſides being much more capacious than thoſe which open into the uterus, are alſo edged round by fringe or finger-like *fimbriæ*, of a truly ſingular and elegant ſtructure.

The

The offices which theſe fimbriæ are deſtined to perform, in the buſineſs of conception, appear to be indeed of no ſmall degree of importance; thus being rendered, during the venereal orgaſm, equally turgid with the tubes themſelves, they evidently embrace, in this ſtate, the *ovaria* that are ſituated in ſome meaſure beneath them.

§ 541.

The *ovaria* themſelves, or the *female teſtes*, as they were called previouſly to the time of Steno, beſides a tenacious and ſomewhat tendon-like involucrum, conſiſt alſo of a denſe and decuſſating cellular membrane, which incloſes in each ovarium about fifteen of thoſe minute bodies denominated the *ovula*, or little eggs of Graaf: theſe ovula contain each a ſmall veſicle, or rather drop of ſerum, faintly yellowiſh in its colour, and of an albuminous nature, which, if the recent ovarium be immerſed in boiling water, is reduced, like the genuine white of eggs, to a ſtate of complete coagulation.

§ 542.

An albuminoid drop of this kind appears to be indeed the principal fluid which the female contributes towards the proceſs of conception; for it appears extremely probable, that, throughout the progreſſive courſe of what are termed the prime

or

or better years of life, these small drops arrive at complete maturity in gradual succession, so that each one, in its turn, looks as it were through the involucrum, by which the ovarium is enveloped, till it is able finally to burst the parietes of its prison, and thus be received by the abdominal orifice of the Fallopian tube.

§ 543.

But besides this minute albuminous drop that thus bursts from the volume of the ovarium, it appears that there occurs also, during the venereal œstrum, an effusion of another liquor, which ancient physiologists very improperly and erroneously denominated the *female semen.* Respecting the nature, however, the sources, and the universal presence of this humour, we are able to propose nothing more determinate or satisfactory than we can advance with regard to its destination and uses.

SECT.

SECT. XLII.

OF MENSTRUATION.

§ 544.

A VERY frequent and highly important function of the uterus in the female of the human ſpecies is, to diſcharge *monthly* a tributary effuſion (called therefore *catamenia*), during the tedious and momentous term of about thirty years. This is a painful condition of exiſtence, to which nature has not ſubjected any other genus of her ſubjects, throughout the wide and diverſified range of the whole animal kingdom; ſo that to uſe the words of the eloquent Pliny "the only *menſtruous* "animal in nature is woman." From this *condition*, on the other hand, painful as it is, nature has not exempted the females of any of the known nations of the globe, but has ſtamped it with the ſacred character of an eſſential requiſite—of a genuine *ſine qua non*, in rendering the female ſex competent to the propagation of their ſpecies.

§ 545.

The commencement of this ſingular function generally takes place, in our climate, about the fifteenth year of life, and is, for the moſt part, preceded by various and unequivocal ſymptoms of

of plethora, ſuch as congeſtion and anxiety about the breaſt, ſenſe of tenſion and weight in the lumbar region, laſſitude or wearineſs of the limbs, &c. On the firſt appearance of the catamenia, the genital organs, in the beginning of the attack, uſually diſcharge a humour of a pale reddiſh caſt; this is gradually ſucceeded by a liquid of a more intenſely florid and ſanguineous colour, which terminates, at length, in an effuſion of genuine cruor or red blood. This ſpontaneous, though gentle diſcharge of blood, is kept up for the term of ſeveral days, and is, in the mean time, accompanied by a gradual ceſſation of all thoſe diſtreſſing ſymptoms of which we have juſt exhibited a partial detail.

§ 546.

From the time of its firſt occurrence, this *conſtitutional hemorrhagy* (as it may, with ſufficient propriety, be denominated) becomes regularly periodical: thus its future paroxyſms return uniformly about the expiration of every fourth week, and at each recurrence, the evacuation continues, at a mean calculation, about ſix days; during which term, a healthy female is ſuppoſed to diſcharge from eight ounces to an entire pound of blood.

§ 547.

§ 547.

It is proper, however, to obſerve, that this function is ſubject, for the moſt part, to an entire intermiſſion, during the ſtate of female pregnancy, and the term of maternal lactation.

The final *ceſſation* of the catamenia occurs after their diſcharge has continued, at ſtated periods, about the ſpace of thirty years, which term of time is completed, in our climate, about the 45th year of life.

§ 548.

The *ſources* of the catamenial diſcharge have been referred by ſome to the veſſels of the vagina, and by others (with ſuperior weight of evidence on their ſide) to thoſe of the uterus: for with regard to thoſe examples commonly adduced in ſupport of the former opinion, where women, although pregnant, poſſeſſing an imperforated uterus, or diſtreſſed by a prolapſus of that organ in an inverted ſtate, have notwithſtanding menſtruated with uniform regularity, they tend to prove nothing elſe than the powerful efforts of the *vis medicatrix naturæ*, which in caſes where the main ſtreet is obſtructed, is (to adopt a vulgar mode of expreſſion) fortunately acquainted with the routes through lanes and alleys. There are on record, on the other hand, numerous *diſſections*

of

of females who died during the term of actual menstruation, from which it was unequivocally ascertained, that the catamenial discharge had been wept out of, or discharged in a stillicidious manner from, the uterine cavity of these subjects: not to mention the arguments drawn *a priori* (as metaphysicians express themselves), from which it appears highly probable, that the end and destination of the menses are, to prepare the uterus for a state of future pregnancy, and render it more fit for the regular nutrition of the fœtus. For the very same reasons also this hemorrhagy appears to be attributed, with more propriety, to the *arterial* than to the *venous* vessels of the uterus.

§ 549.

With regard to the *causes* of this periodical and perennial hemorrhagy, they are shrouded by so thick a curtain of obscurity, and their investigation is attended with such momentous difficulties, that in the prosecution of this subject, we have not a sufficient power of evidence to conduct us over the arduous mound which divides the twilight-region of *probability* from the more luminous realm of *demonstration*, and *certainty*.

The proximate cause physiologists suppose to be a certain topical congestion or plethora, to which

opinion, indeed, the ſymptoms of the impending catamenia, together with the profuſion and nature of the uterine blood-veſſels fitly enough correſpond, and in favour of the truth of which they exhibit a degree of teſtimony ſufficiently reſpectable.

Among its remote cauſes it will be proper to enumerate, the erect poſition of the body (a poſition that ſerves as a characteriſtic diſtinction between the human ſpecies and moſt other deſcriptions of animals); to which we muſt add, the ſingular parenchyma of the uterus itſelf, and, finally, the *vita propria* or ſpecific life of that important organ.

With regard to the cauſe of the periodical recurrence of the catamenia, it will here be better, much better to acknowledge our ignorance, than to indulge ourſelves in vague and viſionary conjectures, and ſportively range through the fair but fallacious fields of mere ſpeculative hypotheſis. For I am, indeed, perſuaded, that all thoſe periodical phenomena which occur in the animal body, whether in health or diſeaſe, *(provided their interval extend beyond the term of 24 hours)* muſt be ranked with thoſe *latent myſteries* of animal nature, which nothing but time, talents, and induſtry, will be ever able to develope.

SECT. XLIII.

OF THE MILK.

§ 550.

BETWEEN the female *mammæ* and uterus (the former of which were, by the philosopher Favorinus in his communications to Gellius, elegantly and emphatically denominated, *the sacred fountains that nourish the human race*, there exists such an extremely potent sympathetic connection, that these two organs may be said to be indissolubly associated, or to accompany each other hand in hand, in their phenomena and functions. Thus, during the tender period of infancy, so great is their imbecility and want of action, that they are capable of performing scarcely any function at all: as the years of puberty advance, they begin, at the same time, to acquire vigour and activity, so that on the first eruption of the catamenia, a swelling of the mammæ or breasts becomes also evident to the senses. Throughout the subsequent periods of life those two organs are either subjected to simultaneous and similar changes, as when the breasts become turgid and discharge milk during the progress of pregnancy; or experience alternate and opposite affections,

instances

inſtances of which we have in the ſuſpenſion of the catamenia during the term of lactation, a more copious effuſion of the *lochia* when the ſecretion of milk does not commence at the uſual period, &c. And, laſtly, on the unwelcome acceſſion of old age, both the preceding functions fail at the ſame time, ſo that when the catamenia finally retreat, never again to return, the uterus and mammæ become *equally* flaccid, inert and wholly incapable of their former action. A great variety of pathological phenomena, eaſily obſervable in caſes of irregular menſtruation, in *fluor albus*, and other ſimilar affections, ſhall be in ſilence pretermitted, although they furniſh the moſt potent and unequivocal teſtimony in confirmation of the ſympathy now under conſideration, namely, that which exiſts between the uterus and mammæ.

§ 551.

Nor will this intimate ſympathetic connection, which ſubſiſts between the uterus and mammæ, appear in any meaſure extraordinary or ſurpriſing, when we conſider, that all thoſe diverſified *ſources* of phyſiological conſent, particularly enumerated on a former occaſion (§ 54), jointly co-operate in the eſtabliſhment of ſuch connection between theſe organs of the female thorax and abdomen.

§ 552.

The anaſtomoſis obſervable between the internal mammary and epigaſtric arteries, was formerly eſteemed a circumſtance of the higheſt importance in the explication of the foregoing conſent. Although phyſiologiſts have hitherto attributed by far too much to this remarkable anaſtomoſis, yet that it ought not to be entirely excepted from the number of co-operating cauſes will appear extremely probable to any one who conſiders the obvious and wide difference which exiſts between the diameter of the epigaſtric artery in a ſtate of pregnancy, and that of the ſame veſſel during the period of lactation.

§ 553.

The two preceding organs, namely, the uterus and mammæ, poſſeſs alſo, in common with each other, this further property, that they both retain and exhibit a friendly affinity or attraction for the chyle, by which means they ſolicit that fluid to themſelves, eſpecially during the term of pregnancy, and thus convert it to peculiar uſes.

§ 554.

The female mammæ conſiſts of a placentoid congeries of ſmall conglomerate glands, diſtinguiſhed by numerous *ſulci* into lobes of conſiderable magnitude, and completely embedded in a maſs of adipoſe

adipofe fubftance. On the anterior part, in particular, a protuberance is formed by a more firm febacious cufhion, which is covered and protected by a cutis of a very tender and delicate texture.

§ 555.

Each one of thefe lobes is compofed of a number of inferior lobuli, and thefe again of what are denominated *acini* or *kernels*, in which the incipient radicles of the *lactiferous ducts* originate, and from the extreme *ramuli* or branches of the internal mammary artery extract a chyliform fluid, which they are particularly deftined to convey.

§ 556.

The fine filiform radicles uniting fucceffively in their onward paffage, terminate finally in leading trunks, correfponding in number to the principal lobes; fo that they generally amount, in each mamma, to about fifteen or perhaps a few more. Thefe trunks are frequently dilated into more fpacious finufes, but never appear to be connected by genuine anaftomofes.

§ 557.

Thefe trunks terminate in excretory canals of exquifite delicacy and tendernefs, which, being collected and clofely approximated towards the centre of the mamma, form, by the co-operation

of cellular membrane, the *papilla* or nipple. This projecting papilla being interſperſed and minutely pervaded by an infinitude of blood-veſſels and nerves of extreme fineneſs and ſubtlety, is ſubject to a very ſingular ſpecies of erection on the acceſſion of certain external ſtimuli.

§ 558.

The nipple is ſurrounded by an *areola* or ſmall circle, which is conſpicuous, as well as the papilla itſelf, on account of the ſingular colour of the *reticulum mucoſum* expanded immediately beneath the epidermis or cuticle. This areola is further diſtinguiſhed by ſmall ſebaceous follicles, and likewiſe by a few minute lactiferous ducts with which it is in ſome inſtances pervaded.

§ 559.

The *human milk* which is ſecreted in the glandular organs hitherto deſcribed, is a fluid of a well known colour, ſomewhat watery, and containing alſo a ſmall portion of oil: this liquid is ſweetiſh to the taſte, extremely mild, and reſembles, in its general properties, the milk of domeſtic animals belonging to the claſs mammalia, except that it is not, like the latter, ſubject to coagulation from the action of acids, nor does it exhibit, to the moſt attentive obſervation, the ſlighteſt veſtige of *volatile alkali.*

§ 560.

§ 560.

When coagulated, however, by the influence of ſpirits of wine, it exhibits the ſame component elements of which the milk of thoſe other animals already mentioned is known to conſiſt. For beſides the *watery* halitus which human milk emits when recently drawn, and yet in a tepid ſtate, its *ſerum*, ſeparating from the *caſeous* or cheezy portion, contains alſo the ſugar of milk, which is compoſed of the ſaccharine acid united to a calcareous earth, together with certain additional parts oily and mucaginous in their natures. Laſtly, it contains alſo a *cream* or butter-like portion, the globules of which are extremely various and changeable in their magnitudes, thus vibrating in their diameters from the $\frac{1}{200}$th to the $\frac{1}{600}$th part of a line.

§ 561.

The analogy which is obſerved to exiſt between chyle and blood, and between each of theſe liquids and milk itſelf, renders it ſufficiently probable, that this laſt humour, (which conſtitutes at preſent the more immediate object of our conſideration), is a ſpecies of chyle renovated from the volume of *blood*, or rather ſeparated from this crimſon fluid (with which it had juſt formed a junction) previouſly to its final and complete aſſimilation. This opinion, beſides other arguments

which might be advanced in its favour, derives powerful teſtimony from the ſpecific taſtes of ſeveral kinds of aliment being not unfrequently perceptible in the milk of nurſes; and alſo from the chyle-like habit and conſtitution of that watery milk, which not unfrequently exudes from the breaſts of females during the term of pregnancy, and for a ſhort time after the period of parturition.

§ 562.

The reaſon why, during the progreſſive continuance of lactation, this bland food of the fœtus becomes gradually more and more inſpiſſated, rich and oily, muſt be referred chiefly to the lymphatic veins, with which the mammæ plentifully abound: Thus the more profuſe the afflux of *milk*, and the greater length of time this afflux has continued, with the more power and uniformity do theſe lymphatics abſorb its ſerous parts, and convey them back to the maſs of circulating blood, by which means they furniſh the moſt effective aid to the whole proceſs of this ſecretion (§ 476).

§ 563.

During the firſt days after parturition, a very profuſe ſecretion of milk occurs, and (provided the mother *lactates*, i. e. ſuckles her child) is promoted and kept up by the ſuction of the infant itſelf,

itſelf, until the catamenia return, which had for a long time ceaſed to flow (§ 547). The exiſtence of milk in the breaſts of virgins truly inviolate, in the breaſts of new-born infants of each ſex, and even in the breaſts of men themſelves, as well as in thoſe of other male animals belonging to the claſs mammalia, is a phenomenon which not unfrequently preſents itſelf to our obſervation.

§ 564.

A profuſe quantity or accumulation of milk in the breaſts effectually ſolicits its own final excretion, whence a ſpontaneous diſcharge of that fluid is obſerved frequently to occur; this diſcharge is further promoted by the external preſſure of the mammæ, as well as by the ſuction of the tender infant.

SECT.

SECT. XLIV.

OF CONCEPTION AND PREGNANCY.

§ 565.

HAVING hitherto confidered the ftructure of the genital organs peculiarly belonging to each fex, we come now to treat of thofe *functions* or proceffes which conftitute the immediate end and deftination of thefe organs, namely, *conception* and the propagation of the human race. In the order and progrefs of our enquiries into thefe abftrufe and interefting fubjects, we will firft give a plain and fimple narrative of the feveral phenomena obfervable in this admirable and truly divine procefs; and then attempt an inveftigation of the energies from which thefe phenomena appear to originate.

§ 566.

It is, in the firft place, neceffary to obferve, that the fubjects of the human race have not, like moft other animals (all thofe, if I be not deceived, belonging to the clafs mammalia, man alone excepted), any peculiar feafon of the year in which they are unufually prone to venereal enjoyments, but

but are equally liable to experience, at every period and under every varying temperature, the gentle glow of love's diffufive fires.

§ 567.

When therefore, the female of the human fpecies admits the embraces of the male, and while they are thus mutually enwrapt in the ardour of that animal inftinct which far furpaffes every other both in the *univerfality* and the *potency* of its fway, the uterus (if we be not greatly deceived) being rendered turgid by a fpecies of inflammatory orgafm, and animated at the fame time by its own fpecific life, (§ 538.) drinks in, as it were, the *feminal fluid* emitted by the male, and effects a fynchronous difcharge of *that* which is proper to itfelf (§ 543); the fallopian tubes become at the fame time rigid, and with their fimbricated extremities embrace the adjacent ovaria: in one or the other of thefe ovaria one of the veficulæ Graaffianæ is lacerated or burft, fomewhat after the manner of an abfcefs advanced to a ftate of complete maturity, and the albuminoid liquid which this ruptured vefícula contained, being abforbed by the orifice of the embracing tube, is thus conveyed onward into the cavity of the uterus.

§ 568.

§ 568.

This *liquid* being difcharged from the ovary, the external lips of the fmall and recent wound through which it was emitted, are again united by a fine cicatrix, while the remaining delicate vafcular membrane in which the liquid had been enclofed, conftitutes what is called *corpus luteum.* This body appears to be at firft hollow and filled with a quantity of plaftic lymph, that in procefs of time is converted into a flefhy nucleus, invefted by a firm cortex or membrane, which is interfperfed by a variety of minute, yet remarkable blood-veffels.

§ 569.

The uterus being thus impregnated, the canal leading through the *cervex* or neck of that organ, efpecially towards its fuperior or internal orifice, (§ 535.) is completely obftructed, in fuch a manner, that according to the common courfe of nature there is no room left for fuperfœtation.

§ 570.

The internal fuperfices of the uterus appears to be invefted with a flight inflammatory cruft of plaftic or coagulable lymph, (§ 19.) which forms the *membrana caduca*, (called alfo *membrana decidua*), of Hunter.

This

This membrane-like cruſt phyſiologiſts diſtinguiſh into two laminæ or layers; one of which, denominated *lamina craſſa*, inveſts the whole internal cavity of the uterus, except the immediate openings into the fallopian tubes, and the internal orifice of the cervical canal; while the other is the growth of a later period, and appears to be generated in the following manner, viz. after the formation of the *ovulum* is fairly commenced, and this minute body begins to ſtrike its roots into the *decidua*, already mentioned, this ſecond lamina begins gradually to expand, and is thus *continued* from the place where thoſe minute roots begin to pullulate, over the remaining ſuperficies of the ovum, whence it has been diſtinguiſhed by the name of *caduca reflexa*.

§ 571.

Although the *ovulum* be formed itſelf at an earlier period than the embryo which it is deſtined to contain, yet the real organization of the former ſeldom commences earlier than the termination of the firſt week after conception. For I very much doubt, whether or not, at an earlier period than this, any unequivocal veſtige of an organiſed body has been ever obſerved in the impregnated uterus of the human ſubject.

§ 572.

§ 572.

This ovulum, or little egg, is compofed of two proper membranes, befides that external *adventitious* covering, which it derives from the *caduca* of Hunter.

The proper membranes are, *firft*, an external one, apparently deftitute of blood-veffels, which forms the *chorion* of modern writers. From the earlieft origin of this membrane a great part of its external fuperficies is beautifully fet with knot-like flocculi or minute *piles* of inconceivable elegance, from whence it has been called, *chorion mufcofum feu frondofum*, i. e. the *mofs-like*, or *leaf-like*, *chorion*. By means of thofe delicate piles, which conftitute the rudiments of the fœtal part of the future placenta, the ovulum is inferted (as if by roots) into the *decidua uterina*. (§ 569.)

The other membrane, lying interiorly, is denominated the *amnion*, which is alfo deftitute of blood-veffels, (§ 5.) it is indeed delicate and tender, but yet of remarkable tenacity and ftrength.

§ 573.

For a few weeks after the firft formation of the *ovulum*, its two proper membranes differ very widely from each other in point of fize, the chorion exhibiting the appearance of a *larger* bladder,

bladder, to the infide of which the amnion adheres under the form of a *fmaller* one, and is attached in particular to that part which is oppofite to the centre of the external floccofe fuperficies of the chorion.

The interftice which then exifts between the *chorion* and *amnion* is filled with a very fubtle chryftaline water, of doubtful origin, and tranfient continuance.

For when the *amnion* begins, during the firft months after conception, to increafe with greater rapidity than the chorion, and to gain on the latter membrane in point of magnitude, this chryftaline liquor muft neceffarily undergo a fynchronous, and perfectly correfpondent, diminution.

§ 574.

The internal membrane of the ovum, from the earlieft period of its formation (§ 570), till the final clofe of parturition itfelf, is conftantly filled with a fluid, denominated by phyfiologifts, *liquor amnii.* This liquid is aqueous, and of a pale yellowifh colour; it emits fcarcely any odour, and is to the tafte *bland*, with a flight faline impregnation hardly perceptible; phyfiologifts generally fuppofe it to be a fource of nourifhment, and compare it to the white of an egg, from which it

notwithftanding,

notwithſtanding, differs in a very obvious and eſſential manner, as may be eaſily demonſtrated by an attentive experimental inveſtigation.

The ſources of this fluid are as yet doubtful: It is certainly, however, neither derived from the fœtus nor the umbilical cord, as it is not unfrequently found in abortive ovula, which contain neither of theſe bodies.

The quantity of this fluid is in an inverſe proportion to the bulk of the fœtus. Thus the ſmaller and more tender the embryo, the more profuſe is the volume of *liquor amnii*, and vice verſa.

Hence we are at liberty to hazard a conjecture reſpecting the primary uſe of this liquor, which appears to be ſubſervient, not ſo much to the nutrition, as to the protection and defence of the minute body of the tender embryo, as yet in a gelatinous ſtate, and, therefore, wholly unable to bear the violence of external injuries. With reſpect to that ſmall portion of the *liquor amnii*, which has been ſometimes (though ſo rarely as to deſerve to be eſteemed a preternatural occurrence) found in the ſtomach of the fœtus, it cannot poſſibly be deſtined for the purpoſe of its *nutrition*, as will be obvious to any one who conſiders how

extremely inert and empty the chyliferous ſyſtem of even a more mature fœtus appears, how unfit for, and even how averſe from, the arduous and important proceſs of chylification. To the foregoing circumſtances we might (if neceſſary) ſubjoin various examples of fœtuſes deſtitute of heads, with diverſe other arguments of a ſimilar nature, and tending to the eſtabliſhment of a ſimilar reſult.

§ 575.

The *embryo* itſelf, which (ſuſpended by the umbilical cord, as fruit appended to its foot-ſtalk), floats in this liquor, begins to be formed about the third week after conception: it appears firſt under the very ſimple globe-like figure of a ſmall bean or kidney, to which the rudiments of the extremities are gradually ſubjoined, the ſymmetry and ſpecific form farther completed, &c.

§ 576.

According to the uſual courſe of nature, the female of the human ſpecies is *uniparous*, and conceives only one fœtus at a time. She not unfrequently, however, bears *twins*, the proportion of which to ſolitary births is, according to the calculations of Suſſmilch, as one to ſeven. In a caſe of twins each fœtus has its own amnion, but they are both enveloped in a common chorion.

§ 577.

That medium, by the aid of which a reciprocal intercourſe is preſerved between the embryo and mother, are the umbilical cord, and the placenta through which this cord is minutely diſtributed.

§ 578.

The umbilical cord, which appears to be coeval with the embryo itſelf, is indeed very ſtrikingly diverſified, not only in point of length and thickneſs, but alſo with reſpect to the place of its inſertion into the placenta, its varicoſe protuberances, &c. In general, however, it is formed of the ſpiral contortions of three blood-veſſels, namely, a vein running to the liver of the fœtus, and two arteries which originate from the internal iliacs or hypogaſtrics. Theſe veſſels are ſeparated and diſtinguiſhed from each other by cellular partitions, running in various directions, and have their *lights* or diameters frequently ſtraitened by the ſmall nodes or valve-like bodies of Hoboken.

Theſe veſſels are collected and compacted together into a cord by means of cellular membrane, which being filled with a ſingular and very limpid humour, exhibits the appearance of jelly, but is inveſted externally by a continuation of the amnion.

§ 579.

§ 579.

At the place where the *fœtus* is attached to this *cord*, the latter is joined by a peculiar body, which originates from the bottom of the *vesica urinaria* (§ 486.), and pursues a middle course between the two umbilical arteries, namely, the *urachus.* This body is, in the human species, pervious, for at least a short space, and afterwards totally disappears; but in other animals belonging to the class mammalia, leads onward to what is called the *allantois*. Of this allantois the human fœtus appears to be entirely destitute, unless we be inclined to designate by this name that mysterious and transient *vesicula umbilicalis*, uniformly observable in the human ovula, between the chorion and amnion, which (if I be not greatly deceived) Isbr. de Diemerbroek first discovered long before it was seen by Albinus or Zinn. But in more modern times it is discovered too frequently, and with too uniform an aspect in unvitiated and fruitful human ovula, (even to so late a period as the third month after conception), to be any longer considered as an accidental, a morbid, or a monstrous conformation of the part.

§ 580.

The blood-vessels of the cord, of which we have already spoken, pass into the *placenta*, which was formerly said to originate from the leaf-like

 superficies

ſuperficies of the chorion, a membrane attached to, and even inſerted in, the *decidua craſſa:* Hence we perceive that the placenta is a body compoſed of two different kinds of ſubſtance, received from an equal number of ſources. Thus, for example, one kind called the *uterine*, from its immediate appoſition to that organ, is derived from the decidua, and conſtitutes the ſpongy parenchymatous portion of the placenta; while the other belonging to the fœtus, and therefore called the *fœtal* part, is derived from the umbilical veſſels diſtributed throughout the chorion.

At this time the increaſe of the tender ovum is unequal, ſo that the growth of the ſmooth portion of the chorion is greater and more rapid than that of the *muſcoſum* or moſs-like; hence it is evident, that the relative magnitude of the placenta to that of the whole volume of the egg, is greater in proportion as the conception is more recent, and leſs, on the other hand, accordingly as the period of parturition is nearer.

As pregnancy gradually advances, the placenta becomes more and more cloſe and compact in its texture; it is impreſſed with grooves, and diſtinguiſhed into lobes on its *external* ſurface which reſpects the uterus, but is ſmooth and highly poliſhed on its *internal*, which, looking towards the fœtus,

fœtus, is invested or lined by the amnios. With regard to magnitude, thicknefs, figure, and fituation or point of *cohefion* to the uterus, it is fubject to a multitude of diverfities; it is attached, however, for the moft part, to the fundus or bottom of that organ; and is, upon the whole, equally deftitute of both fenfibility (§ 205.) and genuine irritability (§ 307).

§ 581.

Although all phyfiologifts uniformly concur in this, that the *placenta* is the principal organ through the medium of which the tender fœtus is fupplied with nutriment, yet various controverfies have latterly exifted among them refpecting the genuine mode of *its* official action, and its reciprocal relation, as well to the uterus as to the fœtus. From an attentive and impartial confideration of all the teftimony that can be collected on this fubject, the refult appears to be, that there exifts no direct anaftomofis between the blood-veffels of the maternal uterus and thofe of the umbilical cord; but the arterial blood which paffes by a continuous route from the uterus of the mother to that portion of the placenta that owes its origin to the decidua craffa, is there abforbed by the incipient radicles of the umbilical veins, that are diftributed throughout the mofs-like portion of the chorion, and thus conducted into the

venous trunk of the *funis umbilicalis*: while, on the other hand, the blood which is conveyed back from the fœtus by the umbilical arteries, being in like manner effufed into the parenchyma of the placenta, is taken up by the venous radicles of its uterine portion, and thus finally re-conveyed into the fubftance of the uterus itfelf.

The foregoing opinions receive additional confirmation from the many well guarded but fruitlefs attempts that have been made by different phyfiologifts to inject the veffels of the umbilical cord through thofe of the uterus, or, on the other hand, to fill the *veffels* of the latter organ by injections forced through *thofe* of the former. As a further evidence in fupport of the fame principles, we may mention the difference which is obferved to exift between the pulfe of the mother and that of the fœtus before their final difengagement from each other; and laftly, it may not be improper to add, as a circumftance tending to the eftablifhment of the fame refult, the obfervations which we formerly delivered refpecting the difference between the nature of the fœtal and that of the maternal blood (§ 147).

But further, it appears probable that a portion of chyle is alfo conveyed to the fœtus along with the blood of the mother. For befides the confideration,

ration, that the blood of the mother is not at all times equally pure and unmixed, but, for fome hours after every meal, carries along with it, in an unaffimilated ftate, that portion of chyle recently received from the thoracic duct, it has been demonftrated, on a former occafion, that the uterus itfelf poffeffes a fingular and ftrong affinity to the chyle and milk (§ 550. 553.); and there are alfo on record a great variety of obfervations, from which it appears, that a milky juice has been actually difcovered in the uterine portion of the placenta.

§ 582.

During the progreffive advancement of pregnancy, while the fœtus and fecundines increafe fo very remarkably in magnitude, it is obvious that the uterus muft be alfo fubjected to ftriking and remarkable changes. Befides the augmentation of its bulk, fo extremely evident at firft view, thofe changes refpect alfo its *fituation* and *figure*, but affect more efpecially the *texture* of this fingular and important vifcus. Thus, in confequence of the uniform and weighty congeftion of humours which the gravid uterus is obliged to fuftain, it is likewife fubjected to extreme alteration, both with regard to the ftate of its blood-veffels, and

alſo with reſpect to that of its parenchymatous portion, throughout which thoſe veſſels are interwoven.

On the preſent occaſion it may not be improper to obſerve, that in proportion as the impregnated uterus advances in magnitude, its blood-veſſels loſe that mazy and convoluted appearance, for which they are at other times ſo very remarkable, and aſſume courſes much more rectilineal or direct; while at the ſame time they are ſubjected to a conſiderable extenſion of their diameters, and a conſequent increaſe of their real capacities. Thus, even the uterine veins have become ſo extremely capacious and prominent, as to have been miſtaken by numerous anatomiſts for true ſinuſes.

With regard to the parenchymatous portion of the impregnated uterus, it becomes gradually more and more lax and ſpongy, eſpecially where it is in contact with the ovum contained; ſo that towards its fundus or bottom it becomes conſiderably thick, and in a living and healthy female, is greatly diſtended with blood, and poſſeſſes the powers of life in a very high degree. This organ is, notwithſtanding, ſoft at the ſame time, and very widely different in its general habit and appearance from the firm and compact fleſh of the uterus

uterus in an unimpregnated ſtate: this difference is ſtill more ſtriking if the ſubject containing the gravid *uterus* be dead, in which caſe, provided pregnancy be conſiderably advanced, this organ falſely aſſumes in its texture (as was formerly well obſerved by Arantius), a lamellated appearance.

It may not be amiſs, on the preſent occaſion, briefly to enumerate a few more of the moſt important changes to which the gravid uterus is ſubjected, together with the moſt remarkable ones that occur in the ovum and fœtus. Theſe changes we will conſider in the ſucceſſive order in which they appear throughout the ſeries of *ten lunar* months, which period of time is now, with ſufficient propriety, ſuppoſed to conſtitute the moſt natural term of pregnancy.

§ 583.

As we uniformly obſerve the uterus beginning to ſwell ſhortly after the time of impregnation, (§ 567.) ſo being from that period increaſed both in bulk and weight, it deſcends a little deeper into the ſuperior part of the vagina; notwithſtanding this deſcent it ſtill retains its former figure in all, except the following, reſpects, viz. its fundus becomes a little more convex, its *anterior paries* or wall, recedes a little farther from the *poſterior*, and its cavity, which was before very narrow and almoſt

almoſt triangular, now accommodates itſelf to the globoſe figure of the ovulum it encloſes.

About the end of the firſt month, the ovulum itſelf amounts to the ſize of a pigeon's egg, and has the two deciduæ ſeparated from each other, and alſo the ſmall amnion ſituated at a diſtance from the larger chorion: about the termination of the third month it attains the ſize of a gooſe's egg, the caduca reflexa becomes approximated to the craſſa, and the amnion approaches nearer to the chorion. The amnion abounds, at this time, with a profuſe volume of fluid denominated *liquor amnii.* In this liquor the embryo, as yet very tender, and extremely ſmall in proportion to the quantity of the ſurrounding fluid (being at this time ſcarcely equal in magnitude to a ſmall mouſe) appears to fluctuate in a looſe and unſteady manner, and is even now in a precipitate poſition.

§ 584.

About the fourth month after conception, the uterus begins to aſſume more of an oval or ſomewhat globe-like appearance; its neck being more and more ſoftened, gradually ſhortened, and as it were, deſtroyed, or rather latterly diſtended, it again protrudes upwards, and begins to aſcend from the ſmaller into the larger pelvis. At the ſame time the fallopian tubes themſelves, with the

convex

convex bottom of the uterus being elevated or borne upwards, are thus extended and elongated; theſe tubes are, however, attached and connected ſo cloſely to the ſides of the uterus, that they cannot recede from them, more than one half of their own length; hence, when only viewed ſuperficially, they appear to originate and proceed from the middle of the uterus, which has given birth to a very erroneous opinion reſpecting the aſtoniſhing increaſe of the *fundus uteri*.

From this time alſo the fœtus acquires by degrees ſuch an increaſed magnitude, as renders it more proportionate to the capacity of the ovum, and begins about the ſame period to fix itſelf in a more ſteady and firm poſition, which it preſerves till the very cloſe of parturition: in this poſition its head is placed in a downward direction, and and its face turned towards the lumbar region of the mother, inclining, for the moſt part, ſomewhat obliquely towards the left ſide.

§ 585.

In the middle ſtage of pregnancy, which occurs about the end of the fifth month, the uterus has attained ſuch a magnitude, that its fundus is elevated to a point half-way between the *pubes* and *umbilicus*, and the pregnant ſtate becomes now

obſervable

obſervable from the external appearance of the abdomen.

About the ſame time, the fœtus becomes more perceptible to the mother from the agitative motion of its body, though we are not able to determine, with accuracy and definitude the preciſe period of time at which this motion takes place. It appears now, however, to be more vigorous and active, ſo that, according to the common uſe and acceptation of ſpeech, it may be ſaid to be the unequivocal action of life.

§ 586.

Throughout the five remaining lunar months the uterus, with the fœtus which it contains, make gradually ſtill farther advancements in point of magnitude. Thus, at the end of the ſixth month they reach nearly to the umbilicus or navel; and about the termination of the eighth approach even the ſcrobiculus cordis, in conſequence of farther protruſion upwards. The *cervix uteri* is in the mean time more and more obliterated, reduced nearer to a level with the adjacent parts of that organ, and its parietes or walls conſiderably diminiſh in thickneſs.

§ 587.

Finally, about the end of the tenth month after conception, the uterus being oppreſſed and overpowered as it were, by its own bulk and weight, (its longitudinal axis, amounting in general to 11, and its tranſverſe to 9 inches in length) begins again to ſubſide, and as the period of parturition approaches, its *oſtium* or mouth is gradually expanded, and thus exhibits an orbicular or ring-like opening.

Each membrana caduca, more eſpecially the reflected one, which adheres to the chorion, having been gradually attenuated for ſeveral months immediately preceding, exhibits now a kind of net-like appearance diſtinctly marked by ſhort fibres of a whitiſh colour.

Such is the ſize of the placenta at this advanced period, that its greateſt diameter or breadth amounts to about 9 inches, its leaſt diameter or thickneſs to about one inch; and its weight to about one pound, and ſometimes more.

The length of the umbilical cord for the moſt part equals, and ſometimes even exceeds, eighteen inches.

The

The weight of a mature and well grown fœtus is nearly ſeven pounds, its length about twenty inches.

The quantity of the liquor amnii is ſo extremely variable, that it cannot poſſibly be aſcertained with any degree of definitude; in general, however, it ſcarcely amounts to a pound, provided the fœtus be healthy and robuſt.

SECT. XLV.

OF THE NISUS FORMATIVUS.

§ 588.

HAVING thus enumerated and deſcribed, in a plain and ſimple manner, the moſt obvious and unequivocal phenomena of conceptions, together with ſuch changes as are diſcovered by attentive obſervation to ſucceed each other, during the progreſſive courſe of pregnancy, not only in the human ovum itſelf, but alſo in the fœtus which it embraces, and contains, we now proceed to an inveſtigation of thoſe phyſical powers, by the influence and efficacy of which the ſublime

ſublime and truly aſtoniſhing proceſs of generation appears to be moſt probably accompliſhed.

§ 589.

There are not wanting certain characters of high celebrity and diſtinction who attempt, even in our own times, to explain the divine proceſs, in the following brief and ſummary manner; they contend that the genuine work of *actual generation* has not, at the preſent time, any real exiſtence at all; on the contrary, they allege, that the whole human race poſſeſſed, under the form of original germs, a joint pre-exſtence in the genital ſyſtem of one or other of our firſt parents, and that theſe germs have ever been, and are yet, ſubjected to gradual *evolutions*, according as the progreſſive lapſe of time, aided by the co-operation of ſpecific cauſes, has contributed to awaken them to the enjoyment of open and actual life.

Unfortunately, however, for the advocates of the foregoing hypotheſis, an eſſential difference of opinion prevails among them on a point of conſiderable magnitude and importance; thus, while ſome of them are anxiouſly in queſt of thoſe *original germs* among the animalculæ that people the ſemen of the male; others are ſearching for thoſe microſcopic animals with no leſs induſtry and zeal in the ovaria of the female.

§ 590.

§ 590.

To the latter of thefe *fects* in phyfiology, I muft acknowledge that I myfelf was formerly an adherent. I was lead to adopt the *opinion* of this learned body not only by the refpectable authority of its numerous advocates, but alfo by the want of *another* more rational and fatisfactory. At prefent, however, I am obliged to repudiate this doctrine entirely, to confefs my errrors, and endeavour if poffible to correct them; having been fully convinced, from a more clofe and minute attention to the phenomena of generation, that nature performs this procefs in a manner quite different from that contemplated and embraced in the theory now under confideration.

§ 591.

For I am indeed daily more and more convinced, that all living organized bodies poffefs, from their earlieft effort at organization to the clofing glafs of their exiftence, a peculiar power perpetually active, perpetually efficacious, the immediate deftination of which is, firft, to mould the bodies in which it refides into their native and fpecific forms by the myfterious procefs of *generation*, to preferve them afterwards from deftruction by the ceafelefs function of *nutrition*, and, in cafe of accidental mutilation, to reftore their parts again, as far as confiftent with the regular efta-

blishments of nature, by the process of *reproduction*. That this energy may not be confounded with the other kinds of vital energy, let it be distinguished by the name of *nisus formativus*. By this name, however, we mean to designate not so much a cause as a perpetual and uniform effect, the existence and reality of which are deduced from actual observations made on the constant and universal occurrence of certain physical phenomena. It is thus, with views, and on principles entirely similar, that we make use of the terms *attraction* and *gravitation*, to denote certain energies or sources of action, the *causes* of which are notwithstanding still involved in more than cimmerian darkness.

§ 592.

To me it appears, indeed, highly probable, that a stated period of time is requisite for accomplishing the intimate mixture, the union and complete concoction or maturity of those various inquiline humours, belonging to each sex, (§ 518. 524. 542. 543.) which are doubtless discharged into the cavity of the uterus, during every act of fruitful coition. This term of preparation having at length elapsed, and the liquors being fully matured and brought into the most perfect state of union and reciprocal influence, the nisus formativus is forthwith excited into action, by means of which the

 spermatic

ſpermatic maſs, hitherto formleſs and chaotic, is partly arranged and organized into the elegant and beautiful envelopes of the naſcent *ovulum*, and partly moulded into the figure of the living embryo which this minute bodies encloſes. From this theory we can aſſign a ſatisfactory reaſon, why the uterus, for the two firſt weeks after conception, appears to contain a maſs of crude and ſhapeleſs humours alone, and does not exhibit, even to our beſt glaſſes (now brought to very high perfection), the ſmalleſt veſtige of an organized embryo, which, notwithſtanding burſts into view almoſt inſtantaneouſly about the end of the third week, and is, even on its firſt appearance, of conſiderable magnitude.

§ 593.

Of the *niſus formativus* we are preſented with more remote veſtiges throughout every department of natural bodies, not excluding even the moſt ſimple elements of matter, where original germs cannot poſſibly be ſuppoſed to have the ſhadow of an exiſtence. Thus, the clouds themſelves aſſume their own determinate forms, and even the ſtreaming torrents or veins of the electric fluid preſerve ſpecific figures. There are, again, in the mineral kingdom, ſpecimens of metallic chryſtallization, which, if indeed the form alone be conſidered, and the

the prerogative of life kept entirely out of view, bear the moſt ſtriking reſemblance to truly organized bodies.

In teſtimony of the truth of this, we need only mention the curious hypniform cryſtals into which refined or depurated copper ſhoots when firſt reduced to a ſtate of fuſion, or that exquiſitely beautiful ſpecimen of native peruvian ſilver which they call *filicinum* or *fern-like*, from the reſemblance of its figure to that of the plant denominated fern.

§ 594.

In like manner both the animal and vegetable kingdoms afford numerous examples of organized bodies, in which, from their magnitude being ſufficient to render them viſible, from their beautiful and unclouded tranſparency and from the extreme rapidity of their progreſſive growth, the whole proceſs of generation is completely unmaſked as it were, and may be ſubjected to the examination of the naked eye. The reſult of attentive and minute obſervations made on this proceſs in ſuch ſubjects as theſe, will be ſufficient to evince, on the authority of the moſt indubitable teſtimony that, at leaſt in theſe bodies, no germs pre-exiſt. In illuſtration of the above poſition it will be ſufficient to mention

from among the different individuals of the vegetable kingdom, the *conferra fontinalis*. And from thoſe of the animal, the *hydra viridis*.

§ 595.

I ſhould far exceed the limits preſcribed to theſe inſtitutions were I to attempt a minute and circumſtantial detail of the various arguments which, in my view, nature herſelf furniſhes to prove the potent influence of the niſus formativus in the proceſs of generation. It may be proper, however, briefly to ſtate a few of them, the force and efficacy of which will appear ſufficiently evident on the ſlighteſt examination.

§ 596.

The firſt argument I ſhall further propoſe on this ſubject is taken from the hiſtory of thoſe curious and intereſting ſubjects of organized nature denominated *hybrids*. From a very beautiful and celebrated experiment it appears, that, if prolific female hybrids be ſucceſſively through ſeveral generations impregnated by males of any given ſpecies different from the ſpecies of the females, the new offspring will gradually deviate ſo widely from the original form of the mother, and make ſuch evident and effectual ſtrides towards that of the father, as to loſe at length every veſtige of ſimilitude to the former, and become finally, (by a ſpecies

ſpecies of arbitrary metamorphoſis) completely aſſimilated to the external figure and appearance of the latter.

§ 597.

There exiſts a phenomenon or fact relative to the hiſtory and production of *monſters*, (the truth of which is too well aſcertained and eſtabliſhed to admit of a doubt), that merits our attention while on the conſideration of the preſent intereſting and intricate ſubject. It is a circumſtance well known to naturaliſts, that thoſe animal productions denominated *monſters* (moſt of which are ſuppoſed, by the advocates for the celebrated doctrine of *evolution*, to have pre-exiſted in a monſtrous *germiform* ſtate from their original creation)—it is, I ſay, well known, that ſuch preternatural productions, though very frequent among certain ſpecies of animals in a ſubjugated or domeſtic ſtate (more eſpecially among ſwine), are notwithſtanding very rarely found among the original and free-born animals of the very ſame ſpecies, that have never been reduced to an humble ſtate of domeſtication, but ſtill range the commons and wilds of nature, wholly exempt from the tyrannic controul of man.

§ 598.

It is neceſſary further to obſerve, that not only monſtroſities co-eval with the birth of animals, but alſo ſubſequent adventitious *mutilations* and other *ſpecies* of *deformity*, whether produced on the animal ſyſtem by accident or deſign, become now and then completely *hereditary;* and thus, what was at firſt the effect of art alone, may be ſaid to become at length the actual work of nature herſelf.

§ 599.

The phenomena of *re-production* in general are much more eaſily and rationally accounted for, by conſidering them as the reſult of a niſus formativus, than by referring them to the pre-exiſtence of partial or local germs. This obſervation is more fully and clearly illuſtrated, and its truth more forcibly exhibited by an application of it to ſome particular inſtances of re-production, as that of the nails, for example, which after the entire loſs of the *firſt*, are well known to be frequently regenerated on the *ſecond* phalanx of the fingers.

§ 600.

Again, in certain parts of the body where no pre-exiſtence of germs can poſſibly be ſuſpected, we not unfrequently ſee organic parts of a preternatural

ternatural order produced by the *vis medicatrix naturæ*, when rouſed into action in conſequence of *accidental diſeaſes*: As an example, and in illuſtration of this, we may mention thoſe ſmall oſſifications known by the name of *oſſicula Wormiana*, which, in caſes of *hydrocephalus internus*, are formed by the provident powers of the animal ſyſtem, for the purpoſe of arching over and thus completely cloſing the enlarged *fontanel*.

§ 601.

Finally, on comparing with candour, and weighing with impartiality, the various arguments on each ſide of the queſtion, it very evidently appears, that beſides a *power of exciting* to motion and action, which the advocates for the pre-exiſtence of germs attribute to the *male ſemen*, in order to render their favourite theory more ſpecious and plauſible, they muſt alſo beſtow on that fluid *plaſtic* or *formative* powers of the utmoſt extent and influence: Whence it is obvious, that the doctrine for which they ſo zealouſly contend, is of itſelf wholly inadequate to the explanation of the numerous and intricate phenomena of generation, unleſs it be aided by the powerful concurrence of a *niſus formativus*: Whereas, on the other hand, the ſyſtem which we have juſt propoſed on the ſubject is, without the bold preſumption of *pre-exiſtent germs*, fully ſufficient to explain all the multiplicity of phenomena attend-

ant on this divine procefs. Let us then on the prefent, as we fhould on every other point of controverfy, adhere to that doctrine which is moft fimple in its nature, and moft conclufive in its end, from a thorough conviction, that an unneceffary multiplication of entities or caufes is no lefs repugnant to real and practical utility, than to the tenor and fpirit of found philofophy.

SECT. XLVI.

OF PARTURITION, AND ITS CONSEQUENCES.

§ 602.

THE foetus being regularly formed and fafhioned by the energies of which we have hitherto treated, and advanced through the progreffive ftages of its fubfequent growth, till it be brought to a ftate of foetal perfection, muft, after arriving at this particular period of maturity, be finally ufhered into the enjoyment of light and entire life, by the painful bufinefs of *parturition.*

§ 603.

This critical and important *period* arrives, agreeably to the ufual order of fpontaneous nature, (which is the only object contemplated in phyfiology),

logy), about the termination of the tenth lunar month, i. e. about the 39th or 40th week after conception.

§ 604.

When a pregnant female finally arrives at this eventful crisis, she is forcibly impelled to the labour of parturition by an insuperable *necessity*, already said (§ 295.) to be less subject to the controul of the will than that which urges to the performance of any other function belonging to the human body.

§ 605.

With respect to the *causes* of a revolution so determinate and sudden, different and even opposite opinions have been entertained by different physiologists. When we view, and take into attentive consideration, all the attendant circumstances, it appears necessary to refer the cause, which immediately impels to parturition, to an eternal law of nature, which has hitherto received no better explanation than has been given to a great many other physical phenomena, which take place in like manner at regular and *stated periods*; such, for example, as the metamorphosis of insects, the progressive stages of eruptive fevers, their crises, &c. &c. Without subjecting themselves to the just charge of fancifully entering on an absurd speculation,

ſpeculation, certain phyſiologiſts have compared a mature ovum, in the uterus of the human ſubject, to the healthy fruit of vegetables, which when completely ripened, fall ſpontaneouſly from their parent plants, in conſequence of a *ſelf-conſtriction* of the veſſels through which their nouriſhment was conveyed. It has been in like manner obſerved, that as the period of parturition approaches, the human placenta ſuffers a ſlight degree of conſtriction, and becomes thus prepared, as it were, for its impending ſeparation from the ſurrounding uterus.

With regard to the *opinion* entertained on this ſubject by phyſiologiſts in general, namely, that the amazing expanſion to which the impregnated uterus is ſubjected, with a multitude of other impreſſions or impulſive powers of a like nature, act as the genuine exciting cauſes of parturition, it appears to be very clearly and effectually invalidated by a great variety of *arguments*, which may be fairly deduced from the unequivocal phenomena of the animal economy itſelf: of theſe arguments we think proper to mention the following, namely, in numberleſs genuine caſes of extra-uterine conception, where the fœtuſes have been contained, for example, in the Fallopian tubes, or in the ovaria, the uterus has notwithſtanding been attacked by painful and convulſive throws, about the

the termination of the tenth lunar month after the occurrence of ſuch preternatural conception.

§ 606.

Beſides the *exciting*, it is evident that there muſt be alſo the joint co-operation of very powerful *efficient* cauſes, ariſing from the nature and properties of the uterus itſelf, and of the contents which it encloſes.

The *proximate* or immediate and primary cauſe muſt be doubtleſs referred ſolely to the *vita propria*, or ſpecific life of the uterus itſelf (§ 47.)

Of the remote cauſes the leading and moſt conſiderable appear to be, the powerful efforts which are made by the aſſiſtance of the proceſs of reſpiration, and the extenſive conſent or co-operation of the intercoſtal nerve with the other portions of the nervous ſyſtem.

§ 607.

When finally the labour of genuine parturition is excited, its *phenomena* obſerve a determinate and regular order with regard to their commencement and ſubſequent progreſſive courſe. In conſequence of this, they have been divided by accoucheurs into different *ſtages*, of which four have been enumerated by the lateſt writers on the obſtetric art.

§ 608.

§ 608.

In the *firſt* ſtage, the parturient patient experiences a ſlight attack of thoſe peculiar and well-known pains, called in that ſtate *precurſors* or *warnings*, which ſhoot in a direction from the loins to the lower parts of the uterus, and which are indeed felt at intervals, (though with diminiſhed frequency and force), throughout the whole period of parturition: the orifice of the uterus begins, at the ſame time, to be conſiderably dilated, the abdominal tumor ſubſides, an inclination to paſs urine becomes urgent and troubleſome, and a copious diſcharge of mucus takes place from the genital organs, now in a ſtate of diſtenſion and laxity.

§ 609.

In the ſecond ſtage, the pains increaſe, and are now diſtinguiſhed by the name of *preparantes*, or preparatory efforts: the inferior ſegment of the coverings or membranes of the ovum are, at the ſame time, protruded through the uterine orifice into the vagina.

§ 610.

In the third ſtage the pains ſtill continue greatly augmented in their violence, and are now denominated *dolores ad partum* *: They act againſt the

* i. e. The genuine pains of parturition.

uterus with a more violent impetus, and thus potently protrude it downwards, while, at the ſame time the uterus preſſes with ſuch aſtoniſhing force on the encarcerated fœtus, as to occaſion a rupture in the membranes by which it is incloſed.

§ 611.

During the *fourth* and laſt ſtage of parturition, while the patient is agitated with convulſive throws, and tortured with the moſt excruciating pain, ſhe makes, at length, a violent exertion, (not unfrequently accompanied with horripilation, grinding of the teeth, trembling of the knees, &c.), by the impulſive force of which, the head of the emerging infant is urged forward, and finally protruded quite through the external orifice with its face foremoſt: in this unlooked for poſition it is forced to advance, in conſequence of the vertex or crown of the head becoming lodged againſt the arch of the pubes, while its other parts are urged onward, and obliged to revolve on the ſtationary vertex, as on an *axis*, or centre of motion. Thus, amidſt a profuſe diſcharge of blood, the infant is finally excluded from its place of confinement, and introduced to the enjoyment of light and life.

§ 612.

The fœtus being thus happily excluded, the *birth of the* ſecundines ſucceeds, after a ſhort interval,

terval, accompanied, in like manner, with painful, though much leſs violent, throws: this latter birth is, as well as the former, followed by a diſcharge of blood, from that part of the uterine cavity to which the placenta adheres by means of the *craſſa* or *groſs membrana decidua*.

§ 613.

The uterus, being thus, at once delivered of its two-fold birth, by which it had been encumbered and oppreſſed, is now contracted by little and little, till it is finally reſtored to its former figure, and reduced almoſt to its former ſize.

§ 614.

During the firſt week after the birth of the child, there exiſts, from the genital *organs* of the mother, an uninterrupted effuſion of the *lochia*, a diſcharge very much reſembling the catamenia, except that it is more profuſe in quantity, eſpecially when not in any meaſure checked or diminiſhed, by the commencement of lactation. The bloody or florid colour of the liquid diſcharged by this evacuation is, notwithſtanding, changed about the fourth day to a pale red, and from thence paſſes on to aſſume a white appearance.

As ſoon as the uterus is thoroughly cleanſed of all remaining fragments of its deciduous membrane,

brane, and has thus finally completed the painful and tedious taſk of propagation, it may again reſume the natural proceſs of *menſtruation*, or even return to the performance of freſh immolations on the altar of conception itſelf.

SECT. XLVIII.

OF THE DIFFERENCES BY WHICH THE HUMAN SUBJECT IS CHARACTERISED BEFORE AND AFTER BIRTH.

§ 615.

FROM what has been already ſaid reſpecting the mode of life enjoyed by the fœtus, while yet encarcerated within the parietes, and immerſed in the warm-bath of the maternal uterus, it is extremely obvious that an immenſe difference muſt exiſt, between the functions of the animal economy in this ſtate, and that which ſhortly ſucceeds, when the infant is finally introduced, by birth, into entire life, and is poſſeſſed of a power of ſpontaneous motion. An enumeration and ſtatement of the leading points or circumſtances of this difference, conſtitutes the deſign of the preſent ſection.

§ 616.

§ 616.

To begin then with the circulation of the blood, it muſt be obſerved, that the *route* of this crimſon fluid is different in the *fœtal* ſtate, from what it is in *that* which immediately ſucceeds paturition or birth. During the continuance of the former ſtate, the *fœtus* is connected, and preſerves a circular intercourſe with the uterine placenta, by means of the umbilical cord; it has never, as yet, inſpired air for the purpoſe of ſupplying the blood with that vital pabulum, a proceſs which immediately commences and is uniformly continued after birth, when this reciprocal connection between the mother and child, is finally deſtroyed.

§ 617.

The umbilical vein originating from the placenta of the mother, and paſſing through what is called the umbilical ring of the fœtus, directs its courſe towards the liver, where it diſcharges its blood into the ſinus of the vena portarum; from thence the blood is diſtributed in part, by the ramifications of this memorable vein, throughout the liver, and in part, conveyed by a direct route through the *ductus venoſus Arantii*, to the *inferior* or aſcending vena cava.

The two foregoing canals, namely, both that portion of the umbilical cord which is contained

in the abdomen of the fœtus, and alſo the ductus venoſus mentioned above, ſuffer after birth an entire obliteration of their cavities, and aſſume the nature and appearance of ſolid cords, inſomuch that the former conſtitutes what is denominated the *round ligament* of the liver.

§ 618.

When, in the fœtus, the blood is conveyed from the inferior vena cava to the right ſide of the heart, the greater part of it is denied a paſſage from thence through the lungs, and is therefore directed towards the left or poſterior auricle of the heart, by the valve of Euſtachius, and admitted into that cavity through the *foramen ovale*.

§ 619.

For over the mouth of the inferior vena cava, after its aſcent from the cavity of the abdomen in the fœtal ſtate, a valve of a lunated figure is extended, which, in honour of its immortal diſcoverer, has been called the valve of Euſtachius. This luniform body is, for the moſt part, gradually obliterated as life advances, although in the fœtal ſtate it appears to perform the important office of directing the blood, emerging from the abdominal cavity, towards an *orifice* to be ſpoken of preſently, which penetrates the ſeptum ſituated between the two auricles of the heart.

§ 620.

The orifice referred to in the preceding paragraph is called the *foramen ovale*, through which by far the greater part of the aſcending column of blood, derived immediately from the inferior vena cava, is conducted into the left *auris* of the heart during each diaſtole of the auricles: of this blood the regurgitation is effectually prevented, by the elegant falciform valve formerly mentioned, which is cloſely ſpread over the foramen, and appears to cloſe that orifice completely, during each ſyſtolic motion of the auricles. During the firſt years of infancy the *foramen ovale* is in part cloſed by means of this ſmall valve, and partly obliterated by the gradual but ſlow adheſion of its ſides: in correſpondence to ſuch adheſion, the valve of Euſtachius itſelf undergoes alſo a ſlow and gradual diminution in point of ſize, till ſcarcely a wreck of it is left behind.

§ 621.

Of that blood which, at the ſame time, enters the right auricle of the heart from the ſuperior vena cava, a very ſmall portion only can be received by the lungs of the fœtus, as yet in a weak and inactive condition: it is therefore taken up by the *ductus arterioſus*, from the trunk of the pulmonary artery (of which this duct is indeed the leading branch) and conveyed by a direct and ſpeedy route

to the arch of the aorta, without paſſing through the lungs at all. Within the courſe of a few weeks after the birth of the infant, the cavity of the ductus arterioſus is, for the moſt part obliterated, and its parietes or walls converted into the nature and appearance of a denſe and firm ligament.

§ 622.

The blood being propelled through the trunk of the aorta, that portion of it, deſtined to be re-conveyed to the ſyſtem of the mother, enters the *umbilical arteries* (§ 578.) which paſs through the *annulus umbilicalis*, on each ſide of the *urachus*, and are, in like manner, after the birth of the infant, converted into ſolid imperforated cords.

§ 623.

As the lungs perform in the fœtus ſcarcely any function at all, their general *habit* and *appearance* differ very materially from thoſe which they aſſume after the infant has commenced the proceſs of reſpiration. Thus, their bulk is proportionably much leſs, their colour more dark, their ſubſtance more compact, and hence their ſpecific gravity ſo much greater, that when immerſed, recent and free from putrefaction, into a veſſel of water, they ſink inſtantly to the bottom; whereas, on the other hand, if the infant has been born in a living ſtate, and taken in air by inſpiration, theſe viſcera,

for the moſt part, float on the ſurface of water, or of any other fluid equally ponderous. The right lobe of the lungs appears to poſſeſs the peculiar prerogative of being dilated a little ſooner than the, left by the incipient influx of air in the firſt act of inſpiration. With regard to the other phenomena of this new function of life, they were enumerated formerly, when we were treating particularly of the proceſs of reſpiration.

§ 624.

From the obſervations which were formerly propoſed on the nutrition of the fœtus (§ 574, 581.), it may be very eaſily perceived that the ſtate and condition of the *alimentary tube* and *chylopoietic ſyſtem*, are extremely different before, from what they are after, the birth of the infant, theſe viſcera being in the firſt caſe inert and wholly incapable of action. Thus, for inſtance, in the tender embryo of only a very few months exiſtence, the *larger*, are perfectly ſimilar in habit and appearance to the *ſmaller*, *inteſtines;* but during the cloſing months of pregnancy the *former* portion of the inteſtinal canal (being conſiderably diſtended with *meconium*) appears to merit unequivocally that name by which it is afterwards diſtinguiſhed from the *latter*.

§ 625.

§ 625.

The *meconium* is a peculiar ſpecies of ſaburra, of a green colour, ſhaded with more or leſs of a browniſh caſt. It is doubtleſs derived from the inquiline humours of the fœtus itſelf, more eſpecially from the bile: that it is indeed of a bilious origin we are induced to believe from the following conſiderations:—*Firſt*, becauſe the earlieſt appearance of this excrementious ſubſtance correſponds exactly, in point of time, with the commencement of the biliary ſecretion; and, *Secondly*, becauſe we learn from accurate obſervation, that ſuch monſters as are deſtitute of a liver, have their inteſtines ſupplied with nothing elſe but a ſmall quantity of colourleſs mucus inſtead of the more common and natural meconium.

§ 626.

In the new-born infant the form of the cœcum is alſo very widely different from what it is in the future periods of life; and this inteſtine is then continued in a direct line with the *appendicula vermiformis*.

§ 627.

Several other differences and peculiarities, of a ſimilar nature, we have already ſpoken of on particular occaſions, and ſhall here, therefore, only

glance on them in the moft brief and tranfient manner:

They are the *Urachus* (§ 579.) the membrana pupillaris (§ 259.) and, in the male fœtus, the *defcent of the teftes* (§ 501.)

A few additional peculiarities will be fpoken of with more propriety in the following fection. Others, as being of lefs importance, we voluntarily pretermit in perfect filence.

§ 628.

The prefent appears to be indeed a very fit and favourable opportunity for calling the attention of the reader to three parts of the human body, altogether peculiar in their nature and obfcure in their deftination, which are of a greater proportional fize in the fœtus than in the adult, and appear to be in a fpecial manner fubfervient to the economy of the former. The true and unequivocal ufes of the parts now in contemplation have not as yet, however, been clearly and fatisfactorily afcertained, although, anxioufly fought after by the combined labours of numerous and very refpectable anatomifts. Thefe parts are defignated by the name of glands, although their *parenchyma* is far, very far, different from the *glandular*, and they have never been difcovered

to

to poſſeſs the fainteſt veſtige of an excretory duct. They are denominated the *thyroid gland*, the *thymus*, and the *renes ſuccenturiatati.*

§ 629.

The *thyroid gland* is ſituated on the anterior ſide of a cartilage of the ſame name, which enters into the conformation of the larynx. It conſiſts of two lobes, and is of a lunated or falciform figure; in the fœtus it is diſtended with a lymphatic fluid, but, as life advances, becomes gradually more and more ſpoliated of its diſtending liquid.

§ 630.

The *thymus* conſiſts of a maſs of ſhining and very tender fleſh, is, in like manner with the preceding ſubſtance, *bilobular*, now and then divided into two diſtinct portions, and contains alſo occaſionally a cavity of conſiderable dimenſions. This body is ſituated beneath the middle and upper part of the ſternum, and aſcends on each ſide even to the throat itſelf; in the fœtus it is large, irregular in its figure, and abounds with a juice of a milk-like nature; but as youth advances it gradually diminiſhes in ſize, until, finally, on the acceſſion of old age, it is ſo completely obliterated as to exhibit ſcarcely a ſhadow of its former exiſtence.

§ 631.

Laſtly, The *Renes ſuccenturiatali*, (called likewiſe *glandulæ ſuprarenales*, *capſulæ atrabiliariæ*, &c.) are ſituated beneath the diaphragm, reſting on the upper extremities of the kidneys. In adults they are not only diminiſhed in ſize, but are alſo removed to a ſmall diſtance from the contact of the kidneys, and contain a dark coloured fluid, which in the fœtus is more inclined to a pale red.

SECT. XLVIII.

OF THE INCREASE, MATURITY, AND DECLINE OF MAN.

§ 632.

HAVING hitherto minutely conſidered the human economy, in detail, agreeably to the ſeveral claſſes into which its phyſical functions are divided, nothing further remains at preſent than to take a general, brief, and comprehenſive ſurvey of man in his tranſit over the diverſified ſtage of life, and thus accompany him, from his earlieſt vital pulſe in an embriotic ſtate, throughout the leading,

leading *revolutions* and *æras* in his economy, down to the final termination of his exiſtence.

§ 633.

Firſt, then, about the third week after conception, the rudimental organization of the embryo appears to take place (§ 575.): about the fourth week afterwards, while the embryo ſtill enjoys an extremely low and languid degree of life, bordering even on that of a vegetable, it is ſupplied with the firſt portion of genuine red blood (§ 13.) The motion of the *corculum* or minute heart, has been but very ſeldom obſerved by phyſiologiſts in the incipient human embryo, but was long ſince diſcovered by Ariſtotle in the incubated chick, and has been, from that period, deſignated by the name of the *punctum ſaliens*.

§ 634.

About the ſeventh or eighth week after conception, the momentous proceſs of *oſteogeny*, or the generation of bone, commences in the human ſubject. Thoſe parts where oſſeous, or bony matter makes the firſt depoſitions for the formation of its *nuclei*, are the clavicles, the ribs, the vertebræ, the long cylindrical bones of the extremities, the mandible or lower jaw, and certain other bones of the face, &c. Thoſe parts again where the oſſeous depoſitions are ſecondary in point of

time,

time, are ſome of the plain bones of the ſkull, ſuch, for example, as the frontal and occipital:—while the bones of the neck, &c. are formed at a ſtill later period.

The younger the embryo is, in particular, or to proceed on a more extenſive and general ſcale, the younger the human ſubject is, whether before or after birth, with the greater rapidity does its growth advance, and *vice verſa*.

§ 635.

About the middle period of pregnancy, the fœtus becomes what may be called a genuine ſubject of *vitality* or life, agreeably to the rule of diſcrimination laid down on that particular point in a former part of this work (§ 585.) About the ſame time, the ſecretion of certain humours make their firſt appearance, ſuch, for example, as the fat (§ 38) and the bile.

§ 636.

As the fœtus advances towards maturity the tender *hair* begins to pullulate, the *nails* emerge into view, the *membrana pupillaris* gives way (§ 260), and in the male ſex the *teſtes* begin to deſcend (§ 505).

§ 637.

§ 637.

About the cloſe of the tenth lunar month, the *infant* is finally releaſed from its impriſonment by means of parturition (§ 603); after which, beſides the aſtoniſhing revolutions in almoſt the whole economy of its ſyſtem, detailed more amply and minutely above, it is alſo ſubjected to various changes in its external habit and appearance; thus, for inſtance, that delicate lanuginous hair, with which the face of the new-born infant is overſpread, diſappears by degrees, its wrinkles are gradually obliterated, its anus retires within the *nates*, which now begin to be ſlowly protruded, &c. &c. &c.

§ 638.

The infant alſo learns, (though indeed by very ſlow degrees), the exerciſe of the various *faculties* of the *mind*, ſuch, for example, as thoſe of *perception*, of *attention*, of *reminiſcence*, of *deſiring*, &c. &c. from whence, in a very few months after birth, it is ſubjected to dreams, &c.

§ 639.

The organs of the *external ſenſes* undergo alſo gradual or progreſſive improvements, and are advanced to ſtill higher and higher degrees of perfection, ſuch as the external ears, the internal nares,

nares, alſo the coverings of the eyes, ſuch as their *ſupra-orbital* arches, their ſupercilia, &c.

§ 640.

The bones of the cranium acquire, in the mean time, an augmented degree of firmneſs. The *fonticuli* or chaſms between the different bones are gradually arched over, and about the eighth month the proceſs of *dentition* commences.

§ 641.

The infant is now ready to undergo *ablactation* or *weaning*, being furniſhed with teeth for the expreſs purpoſe of ſubduing more ſolid food, and not to injure the *papilla*, or nipple of the mother.

§ 642.

About the cloſe of the firſt year, the infant learns to ſtand alone, and ſupport itſelf *in an erect poſition*, the greateſt and moſt enviable prerogative with which the human body is dignified.

§ 643.

The infant being thus removed from its mother's breaſt, and poſſeſſing the uſe and command of its feet, makes daily advances in growth, and improves in the power of ſpontaneous motion, while it acquires, at the ſame time, another very important privilege conferred on the human race, namely, the uſe of *ſpeech*. Ideas which have become

familiar

familiar to its mind it now begins to make attempts to exprefs by the aid of that important organ the *tongue*.

§ 644.

About the feventh year of life, the *milk-teeth*, or firft fet, being twenty in number, drop out by degrees, and are replaced in a feries of years by a fecond dentition, confifting of thirty-two perennial or permanent teeth.

§ 645.

During this period of infancy the *memory* far furpaffes in ftrength and *perfection* the other powers of the mind, and appears to be indeed in a very peculiar manner adapted for receiving and retaining the *figns* of things; whereas after the fifteenth year of life, the glowing powers of the *imagination* ufually gain the afcendency.

§ 646.

This fuperior ftrength and activity of the imagination very happily manifefts itfelf throughout thofe years of life in which the human fubject is, by a variety of ftriking and very important changes in the body, gradually prepared for the future performance of fuch functions as conftitute the characteriftic diftinctions between the two fexes.

§ 647.

§ 647.

Shortly after this period the mammæ or breasts of the female subject begin to swell, the chin of the male becomes clothed in a mantle of coarser down, and a variety of other phenomenon occur in each sex, which serve in like manner to announce the gradual approach of puberty: thus, in the female the *catamenia* begin to flow; while in the male the secretion of a true *semen* commences, which is uniformly accompanied by a more luxuriant crop of *beard*, and a very striking change in the voice from a shriller to a graver tone.

About the same time the *sexual instinct* (§ 289.) that spontaneous and potent call of nature, is first awakened into action, and man, now in the blossom of life, is fitted and inclined to venereal enjoyments.

§ 648.

The *crisis* or precise *period* of puberty cannot by any means be accurately ascertained. It is much varied by diversities of climate and of temperament. In general, however, it occurs earlier in the *female* than in the *male* sex; thus, in our climate females may be said to have arrived at this interesting period against the fifteenth, but males not before the twentieth year of life.

§ 649.

Shortly after the above period the human body finally ceafes to increafe in *ftature;* this particular is alfo influenced and greatly diverfified by difference of climate, not to mention the countlefs varieties that are exhibited relative to this point, not only by different individuals, but even by whole families.

§ 650.

About this period alfo the *epiphyfes*, which had been hitherto diftinguifhed from the bones to which they were attached by very vifible lines of feparation, become fo intimately united to, and fo completely coalefce with thefe bones, that not a veftige is left to ferve as a memento of their former diftinction.

§ 651.

With refpect to the term of perfect *manhood*, which conftitutes indeed the moft lengthy, as well as moft ufeful and important period of human life, we find it characterifed by the higheft degrees of *vigour* and *uniformity*, when we examine the functions of the body, and by that moft invaluable prerogative, *maturity* of *judgment*, when we take into confideration the faculties of the mind. Throughout this interefting period the

lamp

lamp of human life blazes with the higheſt degree of intenſity and ſplendor.

§ 652.

The *heralds* which unerringly announce the intruſive approach of *old age* are, in *females*, the ceſſation of the catamenia, (§ 547.), in *males*, a languid propenſity to venereal gratifications, and in both an invaſion of what is called the *rigidity* or *dryneſs* of old age, with a ſlow but ſenſible declination of the *vis vitæ*, or aggregate power of performing the various functions of life.

§ 653.

Finally, the frigid reign of the ultimate degree of old age is ſtrongly characteriſed by the following concomitant phenomena, namely, a ſluggiſhneſs and increaſing dulneſs of the *ſenſes*, both external and internal, an irreſiſtible call for longer indulgence in ſleep, and a torpidity and languor in all the functions of the animal economy. The hairs aſſume a ſilvery gray, and fall in part from their exalted ſituation. The teeth themſelves drop ſpontaneouſly from their declining ſockets. The neck is no longer able to ſupport the head, nor the tottering legs to ſuſtain the weight of the incumbent body. Even the bones themſelves, thoſe indiſpenſible *fulcra* of the whole machine,

 are

are obliged to bear a part in this irremediable and univerfal decay.

§ 654.

We have thus arrived at length to the remote *ultimatum* of phyfiology, namely, *death without difeafe*, or the *euthanafia of old age*. To conduct and protract human life to this only natural termination (the *caufes* of which are fufficiently obvious from what has been already laid down) conftitutes indeed the *alpha* and *omega*, i. e. the fole and exclufive end and object of the healing art.

§ 655.

The *phenomena* of this *natural death* (as obferved in man when about to refign himfelf to its potent grafp), are, a coldnefs of the extremities, a lofs of the brilliancy of the eyes, a very fmall and flow pulfe, accompanied with intermiffions progreffively increafing in frequency, and laftly a flow refpiration, which by a more forcible act of exfpiration, is at length clofed for ever.

In the live-diffections of animals belonging to the clafs mammalia, there is a convenient opportunity for obferving the laft exertions of the heart, from which it appears, that the right ventricle and auricle of that vifcus refift the encroachments

of death longer, and continue the motions of life to a later period, than the left.

§ 656.

Coldneſs accompanied by rigidity, a cadaverous ſtench, but more eſpecially a flaccidity of the cornea, and a hiatus or gaping of the anus aſcertain in the moſt unequivocal manner the complete death of the body. When in the corpſe an *aggregate collection* of all theſe ſigns occur at once, not even the ſceptical Pliny himſelf could find room to interpoſe the ſhadow of a doubt reſpecting the complete extinction of animal life.

§ 657.

To aſcertain with definitude the natural *term* of the life of man, (or to point out that period which may be conſidered as the more frequent and regular *goal* or *ne plus ultra* of human exiſtence), is, indeed, a matter attended with the utmoſt difficulty. I have notwithſtanding learnt, from examining with care and comparing with accuracy, a great number of bills of mortality, that a conſiderable proportion of ſuch Europeans as are advanced in years reach, but that very few of them paſs, the *eightieth and fourth* year of life.

§ 658.

§ 658.

We may obſerve upon the whole, that in conſequence of the weakneſs and tender ſuſceptibility of infancy and childhood, the intemperance and irregularity of an infinitude of adults, the incontrolable violence of diſeaſes, and a countleſs multitude of fatal caſualties, not more of mankind than ſeventy eight in a thouſand reſign their lives to that ſpecies of *death* now under conſideration, namely, *death* without *diſeaſe.* Notwithſtanding the truth and authenticity of the preceding obſervation, yet on making a genuine eſtimate of *human longevity* and comparing it, under ſimilar circumſtances, with *that* of the other ſubjects belonging to the claſs mammalia, whoſe *natural term* of exiſtence is known to us, it will evidently appear, that, except the baſeleſs declamations of *ſophiſts* regarding the *miſeries* of *human life*, nothing can be more unfounded and irrational than *their* ſplendid and verboſe effuſions reſpecting *its brevity*.

APPENDIX,

IN WHICH IS EXHIBITED A

Condenſed and Summary View

OF THE

EXISTING DISCOVERIES AND SPECULATIONS

Relative to the Subject of, what is uſually denominated,

ANIMAL ELECTRICITY.

STEADY and uniform as the lapſe of time itſelf, are the exertions made by the enterprize and induſtry of man, to ſhed light on the *arcana* or *ſecret proceſſes* of nature. In proportion as ſuch laudable attempts are proſecuted with boldneſs and crowned with ſucceſs, *revolutions* and *improvements* take place in the various branches of phyſical ſcience. Revolutions derive birth from the detection of error, while improvements reſult from the diſcovery of truth. On the repudiation of falſe principles in ſcience, as well as on the developement of new ones deduced from the reci-

procal concurrence of numerous and unequivocal facts, it is not without the sanction of reason and propriety that new systems are forthwith compiled, digested and ushered into the world.

For, to be complete and satisfactory, a system in any branch of science, should embrace and arrange in order all the well authenticated principles spontaneously resulting from facts already ascertained and observations already made, relative to that particular branch. A system less general and comprehensive in its scope than this, should be deemed, at best, but defective and partial, and received as the abortive production of a mind deficient in point of information.

Of the former description was the famous physiological system of Baron Haller, at the time its illustrious author first submitted it to the eye of the world. That excellent physician and philosopher grasped in his acute and comprehensive mind, and detailed at large, in the work to which I here allude, all the authentic and well defined principles resulting from the infinitude of facts with which the science of physiology was at that time enriched.

But all systems are stationary and have been as yet imperfect, while, happily for the interest of man,

man, improvements in ſcience are progreſſive and advancing towards perfection. In the courſe of a few years, ſuch a blaze of phyſical light was diffuſed abroad by the induſtry and ingenuity of philoſophers in general, but of phyſicians and chemiſts in particular, that the deficiencies and errors of the Baron's elaborate ſyſtem were rendered obvious to the moſt weak and inattentive obſerver. In the important *doctrines* reſpecting the *cauſes* of *animal heat* and the *nature* and *purpoſes* of reſpiration, in particular, entire revolutions were effected by the numerous and ingenious diſcoveries of chemiſts in that branch of ſcience denominated aerology.

To ſupply, as far as poſſible, the deficiencies of this ſyſtem of Haller, and to circumvent the errors which the authority of ſo celebrated a character might tend to diffuſe throughout the minds of his numerous readers, became *deſiderata* of no ſmall moment in the ſcience of phyſiology.

The moſt effectual method of accompliſhing theſe deſirable ends was too obvious to eſcape diſcovery. For as violence is moſt effectually repelled by counter violence, and one diſeaſe not unfrequently removed from the animal ſyſtem by the impetuous invaſion of another, ſo in like manner, in ſcience, the defects of one ſyſtem are moſt advantageouſly

ſupplied, and its errors moſt effectually contro-verted and expoſed, by the plenitude and unequivocal certainty of the principles of a rival ſyſtem.

This truth did not eſcape the obſervation of that learned and acute profeſſor, of Goettingen, who now fills the chair which was formerly rendered vocal by the eloquence of the immortal Haller. Need I add, that profeſſor Blumenbach is the man to whom I allude—a man, for the completion of whoſe greatneſs and utility in phyſical ſcience, nature and art appear to have all but exhauſted their abundant reſources! For induſtry and perſeverance in the collection of materials, for powers to combine and arrange materials when thus collected, and for ingenuity and acumen to deduce and ſpeculate from ſuch combination and arrangement, the preſent age certainly boaſts few—too few phyſiologiſts who may be ſet in competition with the illuſtrious Blumenbach.

For this phyſician and philoſopher was reſerved the honourable and important taſk of collecting, digeſting and conſigning to publicity, a ſyſtem of phyſiology deſtined to ſupply the deficiencies and correct the errors of that which had already reſulted from the labours of his celebrated friend and predeceſſor. The ſyſtem of profeſſor Blumenbach was, like that of Baron Haller, perfect and

complete

complete at the time in which it was handed to the world. There exifted not, at that period, an eftablifhed principle, nor fcarcely even a probable conjecture in phyfiology, with which he was not minutely acquainted, and which he did not draw into the extenfive and powerful *vortex* of his fyftem.

Had the fcience of phyfiology been finally complete at the time in which profeffor Blumenbach wrote, the induftry, the immenfe refources and the comprehenfive talents of that philofopher would, no doubt, have quite precluded the neceffity of future fyftems in this branch of fcience. But in the unfathomed depths of the animal economy more *arcana* yet exifted—more *terra incognita* lay yet unexplored, and further refearches of enterprife were therefore effential.

By the combined labours of experimental phyfiologifts in different parts of the world, this branch of fcience was at length matured for giving birth to another *difcovery*, which will probably be found of equal importance, in explaining the phenomena, and in removing the difeafes of the animal fyftem, with that which configned to immortality the name of the illuftrious Harvey. The difcovery to which I wifh at prefent to direct the attention of the reader is that of, what is ufually called *animal*

electricity,

electricity, or, of the exiſtence and operation of a fluid extremely ſimilar to electricity in the living animal ſyſtem. For the fortunate Galvani profeſſor of anatomy at Bologna, was reſerved the honour of lighting *by accident* on this beautiful and divine diſcovery—a diſcovery which entitles its author to be ranked with the great promoters ſcience and the eſſential benefactors of man.

That ſuch a fluid did actually exiſt in the bodies of animals, had been long ſuſpected by phyſiologiſts and other ſpeculative philoſophers. The matter reſted however on pure conjecture alone, and was yet unſanctioned by the teſts of experiment and obſervation. The apparent intricacy of the ſubject depreſſed the hopes of the boldeſt experimenters, and the ſubtlety of the inveſtigation ſeemed to throw an inſurmountable bar in the road to ſucceſs. But *accident* not unfrequently does more for the real advancement of ſcience, than boaſted genius and induſtry are able to accompliſh. It was accident that firſt ſuggeſted to the celebrated Gallileo the conſtruction and uſe of that optical inſtrument denominated the *teleſcope*—It was accident which firſt led the immortal Newton to the original conception of that principle of *gravitation*, by which he afterwards explained, with ſuch facility, the movements and exquiſite balance of the material univerſe. And it

was,

was, in like manner, accident—fortunate accident, that firſt ſuggeſted to the induſtrious and acute Galvani the mode of experimenting, with effect, on the intricate ſubject of *animal electricity*—a ſubject which may poſſibly be deſtined as the only proper clue to conduct future phyſiologiſts to the genuine ſprings and principles of life itſelf.

"Whilſt the profeſſor (alluding to Galvani) was engaged in diſſecting a frog in a room where ſome of his friends were amuſing themſelves with an electrical machine, one of them drew a ſpark from the conductor, at the ſame time that the profeſſor touched one of the nerves of the animal. In an inſtant the whole body of the frog was ſhook by a violent convulſion. The profeſſor was aſtoniſhed at the phenomenon, and believed it owing to his having wounded the nerve; to aſſure himſelf whether this was really the caſe, he pricked it with the point of his knife, without any motion of the body being produced; he now touched the nerve with the inſtrument as at firſt, and ordered a ſpark to be taken from the machine, on which the contractions were renewed. The experiment was repeated a third time, but the animal remained motionleſs; however, upon perceiving he held his ſcalpel by the handle, which was of ivory (a bad conductor), he changed it for

for a metallic one, and re-excited the movements, which he conſtantly failed of doing whilſt uſing an electric ſubſtance.

"After having made a number of experiments with the elect ical machine, he reſolved to proſecute the ſubject with atmoſpheric electricity. To this end he raiſed a conductor upon the roof of his houſe, from which he brought an iron wire into his room, and to this attached metal conductors, connected with the nerves of the animals deſtined to be the ſubjects of his experiments, and to their legs he tied wires, which reached the floor. Conſiderable movements were obſerved in the animals, whether of cold or warm blood, whenever it lightened. Theſe preceded thunder, and correſponded with its intenſity and repetition, and even when it did not lighten the movements took place when any ſtormy cloud paſſed over the apparatus."

"Profeſſor Galvani one day ſuſpended ſome frogs, perhaps with ſimilar views, on metal hooks, fixed in the ſpine of the back, upon the iron railing of his garden; ſeveral times he remarked that theſe animals contracted, and appeared to receive ſhocks; at firſt he conceived the movements were owing to changes in the atmoſphere, but a more ſcrupulous

ſcrupulous examination undeceived him. Having placed a prepared frog * upon an iron plate in his room, and happening with his diſſecting forceps to preſs it againſt the plate, he obſerved the movements to take place. This experiment ſucceeded with all metallic bodies, but more particularly well with ſilver; non-conducting ſubſtances were not proper for it. From this period our author began to ſuſpect the animal poſſeſſed an electricity of its own; and in this ſuſpicion he was further confirmed by the following circumſtance:—He held

* That the reader may not be entirely ignorant of what is meant by a prepared frog, I take the liberty of preſenting him with the following brief extract from the firſt experiment detailed in Dr. Valli's publication: "My firſt experiment was made on a frog, in the following manner: I opened the abdomen in order to lay bare the ſpine of the back, and diſcover the crural nerves which iſſue from it; a few lines above this point I cut the animal in two, and by paſſing my ſciſſars immediately under the origin of theſe nerves, removed the remaining portion of the vertebral column, ſo as only to leave the vertebræ which united the bundle of nerves. Having enveloped this portion of the vertebræ with a piece of ſheet lead, with one end of a metal conductor, I touched the coated part, and with the other the ſurface of the thighs, which had been previouſly ſtripped of the ſkin. The movements were violent, and continued for a long time," &c. In general, throughout the whole of this phyſician's expertmental treatiſe, when one or more of the nerves of an animal are coated with ſheet-lead or any other metal, that animal is ſaid to be *prepared*.

a prepared frog by a hook with one hand, ſo as to let its feet reſt upon the bottom of a ſmall ſilver cup, which he happened unintentionally to ſtrike with the other; at the inſtant the body of the animal fell into violent convulſions. If one perſon held the prepared frog, and another touched the cup, no movements were excited. The profeſſor being now aware of the neceſſity of a communication, undertook a ſeries of experiments for the farther inveſtigation of this ſubject. He firſt placed a prepared frog upon a non-conducting ſurface, and brought one end of a conductor in contact with the hook which ſecured the animal, and with the other touched its feet, on which the contractions took place. When the conducting arch was interrupted by a non-conducting ſubſtance, the frog remained motionleſs, &c."

No ſooner had profeſſor Galvani publiſhed to the world his experiments on animal electricity, than their fame diſpread, ſwift us the intangible fluid which they regarded, throughout the different parts of Europe. Animal electricity became, in a ſhort time, a ſubject of very intereſting ſpeculation to medical philoſophers. Among the ſeveral phyſiologiſts who entered the liſts in this inveſtigation, the moſt diſtinguiſhed whoſe writings have fallen into my hands, are Dr. Valli, an Italian phyſician, from whoſe publication the preceding

account

account reſpecting the firſt diſcoveries of Galvani is extracted, and Mr. Fowler, a native of the iſland of Great Britain.

Doctor Valli appears to have led the van of thoſe philoſophical characters who firſt co-operated with the celebrated Galvani in inveſtigating that animal fluid, the exiſtence of which had been ſo long ſuſpected, but ſo lately realiſed by actual experiment. After repeating moſt of the experiments of his predeceſſor in this branch of phyſics, the Doctor proceeded to a ſeries of new experiments, moſtly conceived and inſtituted by himſelf.

The objects which he appears to have kept ſteadily in view throughout the whole courſe of his experiments and obſervations were, to aſcertain the *nature* of the animal fluid diſcovered by the profeſſor of Bologna, and to determine its *influence* and *medium* of operation in the animal economy. In the proſecution of theſe ends the Doctor has doubtleſs diſplayed all that induſtry and patient perſeverance, ſo eſſentially requiſite in the character who would ſucceſsfully inquire of nature, through the medium of experiment. I am ſorry ,however, to obſerve, that all his experiments were not conceived and inſtituted with equal ingenuity, and perhaps I may add, not executed with equal accuracy and definitude. Many of

many

them appear to have been inſtituted without a direct reference to any ſpecific or particular end— Equally unhappy with regard to conception, indefinite with reſpect to their nature, and inconcluſive in point of reſult, they leave no *impreſſions* on the mind of the reader, ſave thoſe of *diſappointment* and *regret*—regret that a character of ſuch learning and induſtry ſhould, notwithſtanding, interrogate nature with ſo little meaning, and (I am ſorry to add) with ſo little ſucceſs.

The preceding obſervations muſt be conſidered only in the light of *general rules*, and as ſuch, are liable to numerous exceptions. Many of the experiments of Dr. Valli are, doubtleſs, both ingenious and valuable; and I even entertain the utmoſt confidence, that the period will yet arrive, when the whole of them, that are aſcertained and related with juſtneſs and definitude, will be made ſubſervient to the eſtabliſhment of general and uſeful reſults. At preſent, however, they ſtand in an *inſulated* ſtate, completely detached from practical concluſions, and diſconnected from all known principles in phyſical ſcience.

After a ſeries of experiments ſufficiently lengthy and tedious, the Doctor conceived himſelf unequivocally authoriſed to conclude, that the animal fluid of Galvani, was entirely the ſame with the

ſubtle matter of electricity. This concluſion he alleges to be the ſpontaneous and neceſſary reſult of the following poſitions, which he delivers as ſubſtantiated and confirmed by actual experiment.

"First, ſubſtances which conduct electricity, are conductors likewiſe of the nervous fluid."

"*2dly*, Subſtances which are not conductors of electricity, do not conduct the nervous fluid."

"*3dly*, Non-conducting bodies, which acquire by heat the property of conducting electricity, preſerve it likewiſe for the nervous fluid."

"*4thly*, Cold at a certain degree, renders water a non-conductor of electricity, as well as of the nervous fluid."

"*5thly*, The velocity of the nervous fluid is, as far as we can calculate, the ſame with that of electricity."

"*6thly*, The obſtacles which the nerves, under certain circumſtances, oppoſe to electricity, they preſent likewiſe to the nervous fluid."

"*7thly*, Attraction is a property of the electric fluid, and this property has been diſcovered in the nervous fluid."

Having enumerated and detailed the foregoing arguments, the Doctor, in an effusion of triumph, subjoins, " We here see the greatest analogy between these fluids; nay, I may even add, the characters of their identity."

As an additional support to the same opinion, Dr Valli adduces the peculiar and striking phenomena exhibited by the *torpedo*, the *gymnotus electricus*, the *silurus*, &c. which proceed, as he alleges, from a fluid in every respect the same with that which was discovered in frogs, by the professor of anatomy at Bologna. As the Doctor, however, has advanced nothing in confirmation of such entire sameness, save a certain remote analogy which he says he has discovered between the muscles of animals, and the *electrical apparatus* of the torpedo, the gymnotus, &c. it is obvious that this latter argument will but very slightly impress the philosophical physiologist, who founds his belief of principles on *facts*, rather than on vague and visionary *conjectures*.

Having thus, as he supposed, satisfactorily ascertained the identity of the *nervous* with the electric fluid, he next proceeds to speculations on its influence in the diversified movements and functions of the animal economy. To me, however, I must confess, the greater part of this speculative investigation, appears to be rather the effervescent effusions

effuſions of an *imagination*, heated to exceſs in a favourite purſuit, than the ſolemn *deciſions* of a tranquil and unbiaſſed *underſtanding*. I acknowledge myſelf unable, in many inſtances, to diſcern the neceſſary nexus or affinity between his concluſions, and the facts from which they are deduced:—or perhaps I may ſpeak my ſentiments more fully when I ſay, that the learned author appears not unfrequently to have ſubſtituted mere *hypothetical allegations*, for fair and logical *concluſions*—the vacant reſults of his own conjectures, for genuine principles developed by experiment, and aſcertained by obſervation. It very often happens, that by attempting to embrace too much under a ſingle cauſe, we extend the tortured principle beyond its natural limits, and thus, to appearance, weaken or render doubtful its influence, even on thoſe phenomena which it immediately regards. This obſervation applies with too much propriety and force, to the ſpeculations of the indefatigable Valli. By attempting to explain *all*, he has in fact explained *none*, of the phenomena of the animal economy, by that ſubtle fluid on which he ſo patiently experimented. Many of his phyſiological facts and ſpeculations are indeed ingenious and intereſting, but, in my view, they are equally deducible from any other ſeries of experiments, as from that by which they are preceded in the Doctor's publication. Many of the learned author's facts may be, no doubt, true and well

defined, and ſome of his principles and reſults to a certain degree intereſting to the phyſician and philoſopher, but, taken in the aggregate, they are too diſjointed to conſtitute any thing like a ſyſtem, too diſconnected to form a regular chain of inveſtigation. On my mind, his *ſpeculations* on the cauſes of *muſcular motion*, *ſenſation ſecretion* and *nutrition*, impreſs no more ſolid conviction than do *thoſe* of Stahl on the ſubject of his *anima medica*, of Van Helmont reſpecting his ſubtle *Archeus*, or of the airy Paracelſus with regard to his *planetary influence*. Notwithſtanding the apparent ſeverity of the foregoing obſervations, I am ſtill obliged to declare it as my opinion, that the novelty and importance of the ſubject on which Dr Valli has experimented and written, entitle his work to the particular attention of the learned and ingenious of every nation.

For the want of ſyſtem and requiſite deciſion in the writings of the preceding author, compenſation is, in a great meaſure, made by a ſubſequent publication of the accurate and ingenious Fowler. The experiments and ſpeculations of this young philoſopher, on what he terms, the "*influence diſcovered by Galvani*," made their firſt public appearance at Edinburgh, in the courſe of the year 1793: they are not, indeed, ſo numerous as thoſe of the Italian phyſician, but they appear to have been conceived

conceived with more defign, and executed with more judgment. Mr. Fowler feems to have been among the firft who controverted the opinion of Galvani and Valli, refpecting the identity of the nervous and electric fluids: and he has, doubtlefs, controverted it with ability and effect.

Mr. Fowler preliminates his obfervations, with a lucid and forcible ftatement of a certain previous combination of circumftances, which he alleges, muft have ftrongly prepoffeffed the mind of profeffor Galvani, with a belief of the famenefs of the preceding fluids.

That fuch a prepoffeffion muft have had, indeed, a powerful effect on the fubfequent deductions and conclufions of the Profeffor, will be readily acknowledged, by every one who has experienced the influence of preconceived opinions—an influence pregnant with error, and leading countlefs evils in its train.

Mr. Fowler proceeds then to mention the firft object which engaged his attention, in the commencement of his interefting inquiry, and which appears well calculated to pave the way, for the more eafy and effectual accomplifhment of his experimental courfe. This, to make ufe of his own words, was, " to afcertain, as well the va-

rious circumſtances, eſſentially requiſite to the production of theſe new phenomena, as thoſe in which they can be rendered moſt obvious." The iſſue of his enquiry on this ſubject, I will alſo lay before the reader in his own words. "After" ſays he, "a great variety of experiments, of which it wonld be unneceſſary here, to relate more than the reſult, I found, that I could not excite in an animal the appearances deſcribed by Galvani, with any ſubſtances whatever, whether ſolid or fluid, except the metals: and that the mutual contact of two different metals with each other, ſo far as I was able to determine, was in every caſe neceſſary to the effect."

After a ſatisfactory attainment of this object, the ingenious author next proceeds to a judicious ſeries of experiments, with a view to diſcover the genuine nature of the animal fluid, firſt realiſed by the fortunate profeſſor of Bologna. Of thoſe experiments he does not give us a minute ſpecification, but only furniſhes ſtatements of their moſt obvious and ſtriking reſults. Theſe ſtatements he alſo occaſionally interſperſes with intereſting and important remarks, and ſome very ingenious ſpeculations.

Having finiſhed his ſeries of experiments, (a ſeries ſufficiently numerous and diverſified for the eſtabliſhment

ſtabliſhment of general principles) relative to the nature of the nervous fluid, and its affinity to the matter of electricity, Mr. Fowler at length favours us on this ſubject with the following concluſions, which I ſhall take the liberty of preſenting to the reader in the words of their ingenious anthor.

After having ſtated a few analogies between the animal fluid of Galvani, and that poſſeſſed by the *torpedo*, he then reverſes the compariſon, and lays down ſeveral points of eſſential difference, not only between the two preceding fluids, but alſo between the former of them, namely the fluid of Galvani, and the matter of electricity.

"This influence, (ſays he, referring to the nervous fluid of animals) differs, both from that of the torpedo, &c. and from electricity, in producing no ſenſation (in man at leaſt) at all ſimilar to that of an electrical ſhock."

"——That ſome kind of diſagreeable ſenſation is occaſioned by it, even in frogs, independent of that which muſt neceſſarily ariſe from irritation and the contractions of their muſcles, is evident from their reſtleſſneſs and expreſſions of uneaſineſs. In other animals, as I ſhall afterwards have occaſion to ſhew, theſe expreſſions are ſtill leſs equivocal: and in man we can aſcertain both their

degree and their kind. That they differ confiderably from fuch as are produced by electricity will be proved when I come to fpeak of the effects of this influence upon our fenfes."

"But the moft important, and characteriftic difference which I have yet been able to difcover, between this new influence and electricity, confifts in their effects upon the contractile power of animals and of plants. The contractions of animals excited by electricity have a tendency to deftroy that power upon which contractions depend. But the contractions excited, by the application of the metals, have, in all my experiments, had the directly oppofite effect. The more frequently contractions have been in this way excited, the longer do they continue excitable: and the longer are the parts upon which fuch experiments are made, preferved from putridity. An influence, capable of exciting contractions without occafioning exhauftion, was a thing I fo little expected to find, and fo contrary to the character which had been given of this both by Galvani and by Doctor Valli, that I at firft diftrufted my own obfervation of the fact: but the number of comparative experiments which I had afterwards occafion to make, though with views different from that of afcertaining the point in queftion, convinced me that this influence, fo far from deftroying

deſtroying the contractility of muſcles, has a tendency to preſerve it. Oxygene is, ſo far as I know, the only ſtimulus in nature, whoſe effects are at all analogous."

"When a frog has been long dead, I have been ſometimes more than a quarter of an hour without being able to excite a ſingle contraction by the application of the metals: but after this, without at all varying the means employed, contractions have appeared, and have become gradually more and more vigorous."

"It is ſaid (for I have never had an opportunity of making the experiment), that a ſtream of electricity, paſſed through a ſenſitive plant, produces an almoſt immediate collapſe of its leaves. But the influence diſcovered by Galvani produced no ſuch effect in the following experiment. Having ſeparated the leg of a frog from its body, I freed its crural nerves from ſurrounding parts, and with one hand held it ſupported upon the end of a probe. An aſſiſtant placed a piece of ſilver under its foot, and held the zinc with which it was to be touched. A ſenſative plant formed the medium of communication between us. He held the bottom of its ſtem between his fingers, while I held the top; ſo that when the ſilver was touched by the zinc, the influence paſſed up the plant, and

through

through the whole of its ftem. The frog's leg inftantly contracted, and repeated its contractions every time the filver and zinc were brought in contact: but the leaves of the plant did not collapfe; neither did they when any of its branches formed part of the circuit."

I muft however, confefs that the plant, upon which this experiment was made, had been kept through the winter. With a young one the refult might poffibly be different; but fuch an one I have not yet had in my power to procure.

"The torpedo does not appear at all affected by the influence which itfelf produces. Animals in which Galvani's phenomena are produced, are ftrongly affected."

The very ingenious author paffes on next to report the refult of certain experiments which he inftituted, in order to refute the opinion of thofe, who allege, that the fluid of Galvani proceeds entirely from the metallic fubftances ufed, and does not refide at all in any part of the animal fyftem. In his enquiry refpecting this point he difplays the fame fertility in devifing, the fame fagacity in judging, and the fame ingenuity in deducing, which fo forcibly imprefs the reader throughout every part of his experimental inveftigation,

gation. He alſo farther ſhows, that the nervous influence of Galvani, and the ſubtle fluid of electricity differ very materially from each other in the following particular, namely, that againſt the effects of the former, animals are able to guard themſelves by means of a certain voluntary exertion, whereas the operation of the latter is not in the ſmalleſt degree ſubject to the controul or influence of the will.

Having finiſhed the conſideration of the *nature*, Mr. Fowler proceeds to make ſome uſeful *applications*, of the influence diſcovered by the profeſſor of anatomy at Bologna. In his attempts to ſhed light on certain controverted points, and to ſolve certain abſtruſe queſtions, in phyſiology, by means of this fluid, he appears no leſs ingenious and ſatisfactory than in the former parts of his enquiry.

He appears peculiarly happy and concluſive in his reſearches after the *ſource* from whence the nerves and muſcles derive their reſpective powers. I beg leave to lay before the reader two of the author's experiments, inſtituted for the purpoſe of aſcertaining this intereſting particular—a particular which has ſo long furniſhed a ſubject of controverſy among ſpeculative phyſiologiſts. The latter of the two experiments, (to which the former

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ſerves only as a neceſſary introduction) is of itſelf more than equal to all that has ever been advanced on the oppoſite ſide of the queſtion.

Experiment I.

" I divided (ſays Mr. Fowler) the ſciatic nerve of one leg, and tied the crural artery of the other in a large frog. Scarcely any blood was loſt in doing either. Two days after this I ſtrangled it. During the firſt 24 hours, the leg in which the nerve had been divided, appeared to contract with the moſt vigour; after this period the difference between them became more doubtful; but the contractions were at no time ſtronger in the leg whoſe artery was tied, than in that whoſe nerve was divided.

Experiment II.

" The ſame operations were performed upon a large female frog full of ſpawn. Four hours afterwards ſhe was covered by a male, who had been treated in a ſimilar manner. I mention this circumſtance, as it tends to prove, that the pain occaſioned by the operation was probably not ſo great as to produce much fallacy.

" On the day following, ſhe had ſpawned, and on the ſixth day from the operations, ſhe was ſtrangled. When laid upon a plate of zinc, and excited

excited by means of a rod of ſilver, the contractions were found extremely feeble in the leg whoſe artery had been tied, and ceaſed altogether in about twenty-two hours after her death.

In the leg, whoſe nerve had been divided, they appeared as vigorous as they uſually are in legs to which no injury has been previouſly done, and continued excitable upwards of two days after they had ceaſed to be ſo in the other."

It may be proper on the preſent occaſion briefly to obſerve, that the influence diſcovered by Galvani was the teſt uſed by Mr. Fowler to determine the exiſtence or ceſſation of irritability in the muſcles of the animals ſubjected to the preceding experiment. For this influence, as our author judiciouſly obſerves, appears to be indeed by far the beſt and moſt delicate teſt that has ever yet been diſcovered for aſcertaining the loweſt poſſible degrees of muſcular irritablility. After having become wholly inſenſible to the impreſſions of all other ſtimuli, muſcles ſtill continue to vibrate to the kindred touches of this ſubtle fluid, to which nature appears to have given them ſuch a nice, and, perhaps I may ſay, ſpecific correſpondence.

Mr. Fowler, after having tranſiently glanced on the ſubject of inflammation, paſſes on to the attack

attack of a phyſiological doctrine, propagated with zeal, and ſupported with ability by that celebrated experimentaliſt, the Abbe Fontana. The doctrine alluded to, embraces the exiſtence or reſidence of a certain vital principle in the volume of the blood. On this principle, as the induſtrious Abbe alleges, poiſons produce their inſtantaneous effect, when introduced into the vaſcular ſyſtems of living animals. To all the different parts of this phyſical *doctrine* I could never yet be induced to ſubſcribe, notwithſtanding the reſpectability of its learned and numerons advocates.

By attacking and vanquiſhing one of its moſt powerful champions, Mr. Fowler has doubtleſs contributed much to its final demolition. For, in the conteſt now under our immediate conſideration, I muſt confeſs, that to me the laurels of victory appear to be fairly wreſted from the ſilvered temples of the *Italian*, and planted over the youthful brow of the *Britiſh* Philoſopher.

I have thus exhibited a view, ſomewhat general indeed, though confeſſedly very ſuccinct, of the reſults laid down, and of the opinions entertained, by the ingenious Fowler, on the ſubject of the animal influence diſcovered by Profeſſor Galvani. To lay before the reader a full account of all that is uſeful and important in the obſervations of this

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interefting author, would be to tranfcribe and reprint his whole publication.

The only productions in the Englifh language, which this country now furnifhes, profeffedly on the fubject of the animal fluid difcovered by Galvani, are (as formerly obferved) thofe of Fowler and Valli. On the comparative merit of thofe two authors I will here take the liberty of advancing a few general, and, I flatter myfelf, impartial, obfervations:

The experiments of Doctor Valli are more numerous and pompous—thofe of Mr. Fowler more definite and intelligible. The former author appears *often*, the latter, *never*, to have experimented without fome determinate end in view. The experiments of the Italian may be compared to the promifcuous plants of the foreft, ftrewn at random by the fportive and irregular hand of nature—thofe of the young Briton, to choice and valuable collections, arranged with order and elegance, in a well regulated and beautiful garden. The experiments of Valli appear to throw into *fhade*, thofe of Fowler into *light*, the objects which they immediately regard. From the former, the reader collects information with difficulty, from the latter, without labour or painful attention.

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In their deductions and speculations, the two preceding authors are no less dissimilar, than with regard to their experiments themselves. Valli is more diffuse and often hypothetical—Fowler more pointed and generally conclusive. Valli appears to give loosened reins to a glowing imagination—Fowler to be constantly under the steady guidance of a powerful and well-cultivated understanding. The former makes a greater display of learning, and, therefore, too frequently views objects through the more obscure *media* of previous publications—the latter exhibits a higher degree of ingenuity, and derives the principal part of his information, not from pages, sanctioned only by the names of celebrated, yet fallible, authors, but from the great *folio*-volume of *nature*, impressed with her own signature. On the whole, Valli has experimented and written in the most lengthy and profuse—Fowler in the most definite and conclusive manner. In many parts of the writings of the former, nothing else than the *fiat* of an almighty genius would be able to bring *order* out of *confusion*—in those of the latter, lucidity, connection, and regularity, shine pre-eminent through almost every page.

Having thus, without reserve, delivered my sentiments on the *publications of others*, I hope I may be allowed to trespass on the reader's attention

while I make a few obfervations relating to *my own.*

Nothing could have induced me thus haftily to forfake the humble, but fecure, retreats of obfcurity, and rifk myfelf before the eye of the world in the hazardous character of an author, fave a folicitous wifh to contribute to the advancement of medical fcience, and thus aid in acquiring for man a more effectual exemption from mifery and pain. I faw with regret the literary treafures of a Blumenbach concealed from the view of my fellow-citizens beneath the drapery of an ancient and an obfolete language. I was anxioufly defirous to fee the phyfiological fyftem of that illuftrious character completely clothed in the language of my country. I engaged in the tranflation of this work, not becaufe I conceived myfelf better qualified for its execution than others, but becaufe others appeared to me unpardonably remifs with regard to the undertaking. The execution proved laborious and difficult beyond my expectations. The difficulty of detecting an author's precife meaning through the dufky medium of a Latin expreffion, can be fully underftood and realifed only by him who has made the arduous experiment.

Even after the ideas and opinions in the original are fully embraced and completely comprehended, another difficulty of no ſmall magnitude ſtill remains, namely, to convey them to the reader with unequivocal definitude, through the indefinite medium of a different language. It is well known how extremely liable we are to miſapprehend the preciſe meaning of an author who even writes in our own vernacular tongue, much more ſo of one who publiſhes in a language but little uſed in converſation, and, at beſt, but imperfectly underſtood by any man living.

Should the foregoing tranſlation ever fall into the hands of the celebrated profeſſor of Geottingen, I hope he will receive, with candour and indulgence, a well meant attempt to extend the empire of his utility and his fame, by increaſing the number of his admiring readers. If the tranſlation be in any part erroneous, in any part deficient, ſtrictures and corrections will be thankfully received, and punctually attended to in a ſecond edition of the work, ſhould a ſecond be demanded by a patroniſing public.

To preſerve as far as poſſible the firm and energetic ſpirit which characterizes the writings of the illuſtrious profeſſor of Goettingen, and to

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convey to my readers the facts, the principles, the speculations, and the opinions contained in his original work, without even the shadow of alteration, diminution, or addition, has been my steady and uniform aim throughout the whole of the foregoing translation. Owing, however, to the different *constitutions* or *idioms*, as they are more generally termed, of the Latin and English languages, my translation is in many places far—very far from being strictly literal. *Phraseology* I consider, at best, as the mere trappings or drapery of *composition*, while *facts* and *principles* constitute its more substantial and important part. To preserve the latter, therefore, inviolate, and to communicate them with the utmost definitude, is the indispensible duty of a translator, from a principle of justice to the original author, to the public, and to himself; but in my opinion, he is not bound, by any principle whatever, to make an entire sacrifice of all *elegance* and *beauty*, to mere punctilious *literality* of expression. Impressed with the propriety and truth of these sentiments, I have, throughout the whole of the foregoing work, been sometimes *literal* and sometimes *free*, accordingly as the one or the other mode of translation gave birth to a phraseology or stile most agreeable to my ear, and most accordant to the spirit of the original composition.

With respect to the appendix itself, it may not be amiss to make it the subject of a few transient observations. The *principle* which these additional pages regard, and are intended to communicate, is justly becoming, among medical philosophers, an object of primary importance. This principle opens to the view of the speculative mind a rich and spacious field, never yet printed, save by the adventurous steps of a few pre-eminently active and enterprising physiologists—A field, the salutary fruits of which will, no doubt, at a future day, serve to elucidate the nature, to develope the composition, and to alleviate the complicated misery of man.

My whole design in this appendix is to give a condensed, but somewhat general view, of this principle or influence discovered by professor Galvani.

By far the greater number of medical characters in the immense tract of country embraced within the limits of the *United States*, are, in consequence of their distances from literary institutions, excluded from access to public libraries, and situated quite beyond the free circulation of physical science. To such my appendix will serve the humble purpose of a *literary chronicle;* it will convey to them a brief account of the discoveries

which are now going forward in the delightful and important ſcience of phyſiology.

On the ſubject of the influence diſcovered by Galvani I have myſelf inſtituted and performed a conſiderable number of experiments * ; ſome of

* That the reader may be acquainted with an eaſy, cheap and familiar method of experimenting on this ſubject, without having his feelings hurt by the agonizing pangs of tortured and dying animals, I will here take the liberty of inſerting, in form of notes, a few extracts taken from a communication tranſmitted to Mr. Fowler, by his learned friend Mr. Robiſon, profeſſor of natural philoſophy in the univerſity of Edinburgh.

I. "I find (ſays the profeſſor) that if a piece of zinc be applied to the tongue, and be in contact with a piece of ſilver, which touches any part of the lining of the mouth, noſtrils, ears, urethra, or anus, the ſenſation reſembling taſte is felt on the tongue. If the experiment be inverted, by applying the ſilver to the tongue, the irritation produced by the zinc is not ſenſible, except in the mouth and the urethra, and is very ſlight.

II. "If the zinc (finely poliſhed) be applied to the ball of the eye, the brightneſs of the flaſh ſeems to correſpond with the ſurface of contact of the ſilver with the tongue, palate, fauces, or cheek. The ſame thing happens when the ſilver is applied to the eye."

III. "When a rod of zinc and one of ſilver are applied to the roof of the mouth, as far back as poſſible, the irritations

my refults have appeared ftriking and new, but my experiments have been neither fufficiently numerous nor varied to warrant the deduction and eftablifhment of general principles. My prefent intention is (fhould heaven indulge me in life and health), to profecute to fome extent this highly

tions produced by bringing their outer ends into contact, are very ftrong, and that by the zinc refembles tafte, in the fame manner as when applied to the tongue."

IV. "I had been paring my toe-nails with fciffars, and had cut off a confiderable portion of the thick fkin, fo that the blood began to *ooze* through in the middle of the wound. I applied the zinc there, and an extenfive furface of filver to the tongue. Every time I brought the metals into contact, I felt a fmart irritation by the zinc at the wound," &c.

A variety of other experiments of a fimilar nature are contained in the fame communication from Mr. Robifon to Mr. Fowler; but a further detail of them I conceive unneceffary, as the ingenious reader, being acquainted with the foregoing, can with facility devife other experiments for himfelf. Thus I have frequently conveyed to my eye the luminous flafh mentioned by Mr. Robifon, not only from the internal veftments of the mouth, the nofe, the urethra, &c. but alfo from between my fingers, from the cubital flexure of my arm, and from various other parts of my body, where the texture of the cuticle and fkin is more fine and foft than ordinary; always taking care, however, to moiften the part previoufly to the application of the metals.

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intereſting ſubject. Should my inveſtigation be favoured with the diſcovery of any thing curious in ſcience, or uſeful in practice, a detail of it may be expected in a future communication.

To my ſolemn audit before the bar of the public, I now haſten in tremulous anxiety, "with all my imperfections on my head,"—imperfections which will no doubt awaken the cenſure of the critic, but receive, I flatter myſelf, the indulgence of the liberal and candid. The approbation of the former I neither court nor regard; that of the latter it ſhall be my conſtant ambition to deſerve. The profeſſed buſineſs of moſt modern critics appears to be, to condemn—promiſcuouſly condemn, too frequently without the fainteſt ſhadow of either inclination or talents to diſcriminate merit from its reverſe.

In my view the *approbation* of a profeſſed critic is perfectly ſynonymous with the *cenſure* of the liberal and the ingenious, to whoſe candid examination the preceding pages are ſubmitted with all that reſpect and deference due from an inexperienced writer.

THE END.